COMMITTEE REPORTS NUMBER

ELECTRICAL WEST

WITH WHICH IS CONSOLIDATED THE JOURNAL OF ELECTRICITY

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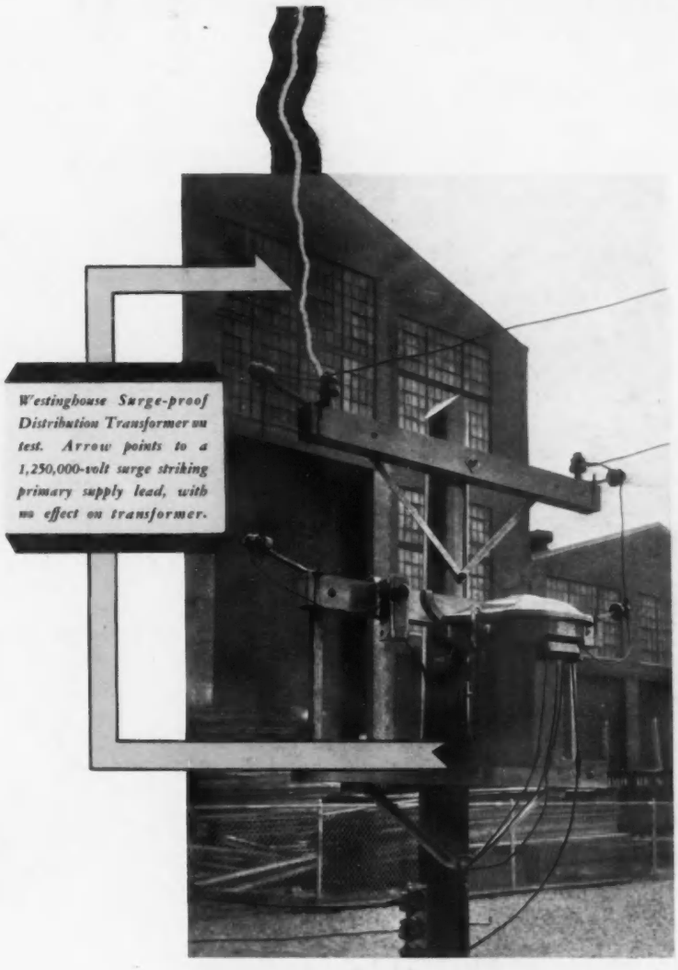

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ELECTRICAL WEST

With which is consolidated the Journal of Electricity

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G. C. TENNEY, *Editor*

Electrical Loaves and Fishes

AND when the five loaves and the two fishes were broken and distributed among the multitude, lo, it was found that every man had received a full portion.

EVEN material things, shared rather than hoarded, have a way of growing until they benefit all concerned in the transaction, the man who gives as well as the man who receives.

IF THIS be true of worldy gifts, it is especially the case with ideas. An idea shared is truly an idea doubled. It receives new impetus from the impact of fresh minds; it grows and develops as could never be the case if it were confined to the particular spot where it originated.

THE electrical industry may well be proud of the perfected forum for the exchange of ideas which is represented by the National Electric Light Association and its various geographic divisions. Here, in the committee room, in the convention and in the annual reports of committees, the various member companies present the best that they have learned from their own experience, glad to pass on their help for the benefit of any who may use it, friend or competitor, sure that they in turn will receive greater benefit than they have given.

ELECTRICAL WEST takes pleasure in presenting this compilation of papers representing the serious work of the committees of the Pacific Coast Electrical Association and the Northwest Electric Light and Power Association during the past year. Read it over with the eye of an outsider, if you can, and be proud of the picture it presents of every man and woman in the industry, concerned with the study of how to do his job better in his own company, working together with every other man and woman in the electrical field to see that the entire industry does its job better, to the end that the public may receive its electrical service a little cheaper, a little more reliably, and may utilize it with greater satisfaction in home and industry.

VERY concrete benefits in the way of new technical advances, the development of new apparatus and the application of new processes have come out of these discussions in the past. The reports here printed contain important contributions in every line of public utility service. They are worthy of your careful study.

Improved Service at Lower Cost

By ADDISON B. DAY

APPROPRIATELY, the Pacific Coast Electrical Association seeks to interpret and represent the electrical industry in the territory which the Association serves. It therefore naturally follows that our activities for the year have reflected somewhat the current economic picture, in stressing the study of the problems of load building and the sale of appliances.

The major present problem of the electrical industry is commercial, rather than technical. Our engineers necessarily have outrun our salesmen in the race toward the goal of practical perfection. This is true, even in normal times, and is much more acutely true in the current subnormal market.

Fortunately, the public utilities have not experienced the same degree of economic distress as industry and business generally. This in a measure compensates for the comparatively less prosperity which the utilities experience in normal times.

The achievements of the Pacific Coast Electrical Association in any year are essentially the sum of the achievements of its sections. During the present year the section chairmen and other leaders have been conscious of their responsibility and have given earnest and effective consideration to the problems by which the industry is confronted. In this brief article, it will of course be impossible to give detailed mention of all that has been done. A few typical examples will serve to illustrate the general trend of thought and action.

ADDISON B. DAY
President Pacific Coast Electrical Association

The Engineering Section has been working to the slogan, "Improved Service at Lower Cost." This principle is basic to the further progress and development of our business; improved equipment for the creation of electric service, and improved appliances for its utilization are the foundation upon which our commercial departments are able to build increasingly greater and more useful structures of public service.

A feature of the section's work this year was a series of mass meetings conducted by the accident prevention committee, and well attended by supervisory employees in the localities where the conclaves were held.

The Commercial Section adopted the old but ever essential objective of increasing the sale and use of current-consuming devices and of building load. Employee education on the very acute subject of Government Ownership was promoted through the annual essay contest, which, from the numerical standpoint at least, appears to be the most successful one which the Association ever conducted.

Education of the public on the subject of good lighting was the active concern of the lighting bureau, which for this purpose employed lectures, literature, and demonstrations.

Intensified effort has been made to promote the sale of refrigerators, ranges, and small appliances. At the same time, there has been a continuous attempt to discourage unethical practices in competitive selling.

Particular attention has been given to studies in farm and oil industry electrification, and plant modernization. A new activity for the year has been the study of air-conditioning, which promises to be an important avenue of future development.

The Accounting Section has maintained its traditional reputation for the thorough study of the aspects of accountancy. It has made important contributions to the understanding and systematization of this most important arm of our business.

The Advertising-Publicity Section has earnestly studied those problems which are peculiar to the advertising and publicity functions of public utilities.

The Transportation Section has devoted its energies to the problems of systematization and standardization, with the general purpose of increased efficiency, in harmony with the spirit of the day and the trend of the times.

The Purchasing and Stores Section has continued its good work in the study of the problems of standardization and simplification, and consequent economy.

The other sections, not here mentioned, have performed their accustomed tasks unobtrusively and well.

The annual convention will be held at Pasadena, June 15 to 17 inclusive. Appropriately this will be a serious meeting of those who feel their responsibility for the welfare and progress of the industry. Naturally the program menu will be spiced with bits of recreation and entertainment, but in the main, the diet will be substantial and nourishing.

Accounting Section[1]

Although only one report is published this year from the Accounting Section, this does not mean that the other committees have not been busy. An extensive report has been prepared by the committee on classification of accounts and also a study of the fixed capital texts of the classification of accounts has been made by the fixed capital committee, both of which texts must await the authority of the Railroad Commission for publication. Programs from all committees will be presented at convention.

*Fixed Capital**

Overhead costs should be distributed to both minor and major items of construction. Capital should bear an equitable portion of the cost of operating employees and their supervision when engaged in construction work. Interest during construction should be capitalized from the date of first expenditures until the project becomes operative. Retirement costs should be based on actual costs when available, otherwise on average yearly costs.

THE work assigned to the fixed capital committee for the past year by the executive committee of the Accounting Section consisted of a study of several subjects which are of particular interest at the present time, since most of the member companies are now experiencing a considerable decrease in the amount of new construction work. The subjects included one assigned by the national accounting committee and at the further request of that committee, considerable work has been done along the lines of revision of the national classification of accounts. The results of the discussion of these various topics are as follows:

General Overhead Expense

Discussion of the most equitable method of distributing overhead costs to construction work brought out a variety of opinions, but in general the committee members agree that costs should be distributed to both major and minor construction work. It is more or less generally admitted that a relatively small amount of overhead is incurred in the installation of minor line extensions, minor additions to plant, etc., but that nevertheless these additions do definitely incur certain overheads such as interest during construction, administration, injuries and damages, and even a small amount of administrative expense. Several members have suggested that recognition be given to these lower costs by the use of a lower overhead rate for minor work, thus giving, in effect, the bulk of the overhead costs to major construction work where most members believe it properly belongs. It is admitted that determination of such a distinction in overhead rates would be difficult, if not impossible.

Most companies at the present time, because of a considerable decrease in construction work, are confronted with a situation in which the overhead costs assignable to construction have decreased only a little and the overhead percentage as a consequence has greatly increased. To overcome this difficulty, it has been suggested that an overhead reserve be created and that a predetermined fixed rate of overhead be cleared from this reserve. One California company has successfully cleared its overhead cost on a flat rate for a number of years, but some companies might find that by using a flat rate there would be periods in which the reserve might show either large debit or credit balances, which from the viewpoint of the regulating bodies might be highly undesirable.

Another objection which has been made to distributing all of the overhead cost to major construction work or using a higher rate for that work, is that a small job, constructed as a part of a major job, would automatically receive a high overhead rate, while the same job constructed after the original job, would receive a much lower rate.

Several members have pointed out the fact that general or schematic overhead costs which relate to the system as a whole and not to individual units, should be handled on an entirely different basis from other overhead costs, in order that these costs may not be retired when individual units of property are retired. While this viewpoint is no doubt reasonable, its application would tend to leave on the books eventually a considerable amount of undistributed overhead which most companies believe is highly undesirable.

As to major construction, such as hydro power plants, for instance, where there are schematic or development costs which are eventually distributed to the completed units of the plant, it is very important that, in the case of future replacements, the original schematic costs should be left intact, i.e., this cost should not be retired along with the particular unit being replaced. It seems necessary, however, on account of depreciation computations, to remove that portion of overhead included in the original installation of a unit, which would be restored by adding a similar amount back through the replacement unit. This latter suggestion, of course, would be governed by the particular depreciation procedure. It does mean, however, that all such so-called schematic cost should be retained in the investment.

To summarize, the majority of the committee members believe that, with the exception of special construction work involving unusually long interest periods, higher engineering costs, etc., distribution of overhead costs in the same ratio to all construction work is the most practical solution of the problem.

Charges to Fixed Capital of Time and Expense of Operating Employees While Engaged in Construction Work

The following method is proposed for equalizing the charge to operating account, and also, the percentages of these overheads to construction expenditures: For the previous five-

---

[1] Executive committee—A. B. Carpenter, chairman. J. A. Cannon, vice-chairman. J. S. Bordwell, H. P. Dayton, E. W. Hodges, D. A. McCullough, H. Painter, L. A. Reynolds, E. N. Simmons, C. P. Staal, H. T. Terry.
Classification of accounts committee—E. N. Simmons, Los Angeles Gas and Electric Corporation, chairman.
Pacific Gas and Electric Company: E. W. Hodges, L. A. Reynolds.
Southern California Edison Company Ltd.: C. P. Staal.
Southern Sierras Power Company: J. S. Bordwell.
Customer billing and records committee: S. A. Northington, Southern California Edison Company Ltd., chairman.
Coast Counties Gas & Electric Company: Fred Lovejoy.
Los Angeles Gas and Electric Corporation: O. L. Moore.
Pacific Gas and Electric Company: F. E. Oldis.
San Diego Consolidated Gas & Electric Company: C. C. Krymer.
San Joaquin Light & Power Corporation: Loris Auld.
General records committee: C. J. Watters, San Diego Consolidated Gas & Electric Company, chairman.
Los Angeles Gas and Electric Corporation: N. H. Bradshaw.
San Joaquin Light & Power Corporation: L. C. Streit.
Pacific Gas and Electric Company: Harry McGann.
Southern California Edison Company Ltd.: D. C. Griffin.
The Southern Sierras Power Company: H. S. Barber.
Statistics committee: W. C. F. West, Los Angeles Gas and Electric Corporation, chairman.

* Report of the fixed capital committee, Accounting Section. Valery White, Southern California Edison Company Ltd., chairman.
Coast Counties Gas & Electric Company: C. L. Kirksey.
Los Angeles Gas and Electric Corporation: Manuel Sandusky.
Pacific Gas and Electric Company: E. E. Dodge, P. C. Miller.
San Diego Consolidated Gas & Electric Company: C. W. DeVoe, C. C. May.
San Joaquin Light & Power Corporation: A. S. Walthall.
Sierra Pacific Power Company: Ray Torvison.
Southern California Edison Company Ltd.: C. N. Rudkin.
The Southern Sierras Power Company: L. B. Reed, E. R. Sims.

year period determine (1) the total of general and administrative expense, net of engineering items specifically assignable to construction account and also (2) the construction prorata thereof, exclusive of items directly charged to construction. Calculate the per cent of (2) to (1). The percentage established will then be applied monthly to the monthly total of general and administrative expense, net of engineering items charged directly to construction account, the amount determined to be charged to the apportionment account (C.R.C. classification No. 134), captioned "overhead apportionment equalization account," and credited to "general and administrative expenses." For the previous five-year period determine the percentage of administrative expense overhead to construction expenditures and also the percentage of engineering expense overhead (exclusive of direct charges to construction account) to construction expenditures. The percentages established will then be applied monthly to the monthly total of construction expenditures, the amount of administrative expense and engineering expense thus determined to be charged to "work in progress" and distributed over the various jobs on a dollar expenditure basis, and the credit to be made to "overhead apportionment equalization account." Theoretically, if the next cycle of five years is comparable to the previous five-year cycle, the "overhead apportionment equalization account" charges will be entirely used up at the end of this period. However, if it is anticipated that the next five-year cycle will not have the same economic characteristics as the past five-year cycle, the factors producing the percentages calculated above will have to be changed to give effect to the prophecy for the new cycle.

Construction Period Over Which Construction Interest May Be Accrued

It is the unanimous opinion of the committee that the utility is entitled to charge interest during construction against a project from the date at which the first expenditures are made until the project becomes operative. In the opinion of the former solicitor of the Federal Power Commission, interests on lands acquired before actual construction work begins and on investigations prior to that time are not allowable as a part of the original investment cost of federal projects.

It is evident that interest upon such investments is actual out-of-pocket cost, and since such property cannot be carried in the rate-base until it becomes operative, the cost of carrying it must either be recovered from interest during construction or must eventually be a dead loss to the utility. It is equally evident that the costs of such investigations are as necessary a part of the final project as the powerhouse itself.

In support of this contention, several committee members have quoted various authorities, the more important ones of which are as follows:

Electrical Companies

C.R.C.—Account 39½—Interest During Construction.

Public Service Commission of Oregon—Interest During Construction.

Interstate Commerce Commission—Interest During Construction.
Federal Power Commission—Interest During Construction.

When any bonds, notes or other evidences of indebtedness are sold or any interest-bearing debt is incurred, for acquisition or construction of plant or equipment, *the interest accruing on the part of the debt representing cost of property chargeable to fixed capital accounts* (less interest if any, allowed on unexpended balances), *after such fund becomes available for use and before the receipt or the completion or coming into service of the property so acquired, shall be included in this account.*

When such securities are sold at a premium, the proportion of such premium assignable to the time between the date of the actual issuance of the securities and the time when the property acquired or the improvement made becomes available for service shall be credited to this account.

This account shall include also such proportion of the discount and expense on long term debt issued for construction purposes as is equitably assignable to the period between the date of the actual issuance of the securities and the time when the property acquired or the improvement made becomes available for the service for which it is intended. The proportion of discount and expense thus chargeable shall be determined by the ratio between the period prior to the completion of coming into service of the facilities or improvements acquired or constructed and the period of the entire life of the securities issued.

Grunsky—Valuation, Depreciation and the Rate Base

Page 52—American Society of Civil Engineers Committee. Interest and Taxes:

Interest upon the capital invested in the plant up to the time when it is first operated and begins to have earning capacity is an unavoidable expense.

Under the most favorable conditions it is necessary to raise the money required for the construction of the work months in advance of its expenditure and in many cases the whole amount must be raised before beginning the work in order to insure against a suspension of operation with the large loss necessarily incident thereto.

Spurr—Guiding Principles of Public Service Regulation

Page 410—Ben Avon Borough vs. Ohio Valley Water Co. (Pa.) P.U.R. 1917 C:

Upon appeal, the Superior Court said that the money used to construct the plant, as the labor employed thereon, demanded its fair return from the moment it left the investor's hands; that during the period of construction the company secured no return for its use; that the interest charges must be met and that this can only be done from the capital account.

Page 408—State Journal Printing Co. vs. Madison Gas and Electric Co. (110) 4 Wis. R.C.R. 501.

In an early case before the Wisconsin Commission it was said that the element of interest during construction theoretically is the current rate for the use of each item of the outlays during the time which intervenes between each such outlay and date of the completion of the plant up to the point of operation; that the sum of these charges, however, is the minimum amount that should be allowed as interest during construction. The commission said that, as a practical question, it would seem inevitable that the actual interest cost might in some cases be even greater than this, for the money might have to be provided in advance of the installation of the integral parts of the plant.

Page 409—Mountain States Telephone & Telegraph Co. (Idaho) P.U.R. 1921 B, 739.

The rate of interest during the construction period in the opinion of the Idaho Commission must be an average if it is to be applied to all physical property. Some classes of property, such as land, buildings, rights-of-way, etc., must be acquired early in the construction period, while such classes as station apparatus, installations, etc., would probably be earning revenues by the time the term of credit on the purchase of the same has elapsed.

W. H. Blood, Jr.—Interest During Construction

Page 298—General Electric Review, May, 1925.

In ascertaining interest during construction there are three variables which must be considered—the rate of interest, the construction period and when the money is raised. There are minor adjustments which might properly be considered when figuring interest during construction. For example, it would be perfectly fair to assume that all the land had to be bought before construction work started, in which case *interest during construction on the land would be figured on the full cost for the full term.*

Rate Making for Public Utilities by Lyndon

Page 110—Interest During Construction.

When the first installation of equipment is made for a public utility, a considerable period of time elapses from the date of organization to the completion of the plant and beginning of operation. The money required to meet all the expenditures is generally assumed to have been paid into the treasury of the company before construction began, and, *therefore, during the length of time, from the date of obtaining the money until the plant begins to earn a return, an interest charge is incurred which must be met, and this is as definite an expenditure for the production of plant as is the purchase of any portion of the equipment itself.*

Opinions and Orders of the Railroad Commission of California

Vol. 18, Decision No. 7446, San Joaquin Light & Power Corp. Rate Case, page 95.

Normally interest during construction is capitalized on new developments until they are put in operation and not afterward, and a utility is entitled to earn upon its property, upon its becoming operative.

Valuation of Public Utility Properties by Floy

Page 110, Interest.

Interest accruing on idle capital, represented either by cash or plant, during the preparation of a public utility property for service, has been repeatedly allowed by public service commissions, and affirmed by the various courts, including the Supreme Court, as a proper expenditure for capitalization.

The total amount of interest allowable, up to the time of beginning operation, is very often taken as the sum of two items figured separately upon:

(a) The cost of the physical plant, including the items of contractors' profit, engineering, incidentals, etc.

(b) The cost of expenditures made in cash under the head of development expenses.

As equally important as the rate, in fixing the proper amount of interest allowable, is the period of time over which it is figured. The length of time estimated, depends upon the rate of construction assumed, which is, of course, governed by the complexity of conditions under which the corporation began operation, the size and peculiarities of the plant, climatic conditions, facilities for the work, freedom from labor troubles and similar allied circumstances. *The period of plant construction extends from the time the first real estate is purchased until the property is in condition to begin delivering output.* Unless construction work is being done in large centers of population or is spread

over a considerable territory, it cannot usually be advanced efficiently and economically at a rate greater than will be covered by the expenditure of about a million dollars a year for labor and ordinary material; of course the installation of large and expensive units of machinery or equipment would increase the investment rate.

Method of Determining Original Cost of Properties to Be Retired

The method of determining the original cost of properties to be retired necessarily depends upon the data which is available to the various companies. Most companies apparently use inventory or valuation costs when available and some sort of average cost otherwise. Most companies agree that average costs for each year provide an equitable basis for retirement costs. Examples of some of the methods now followed are as follows:

Pacific Gas and Electric Co. is fortunate in having a complete valuation of its properties as of 1920, and retirements of property installed prior to that date are based upon the valuation. Cost analyses of property installed subsequent to 1920 are available for practically all of this important property and consequently its retirements are made in practically all cases on actual cost.

Coast Counties Gas & Electric Co. uses original cost when known and believes a yearly average cost basis would be the most acceptable in working out a uniform basis.

San Diego Consolidated Gas & Electric Co. uses values established in its 1915 inventory for construction prior to that time, construction-folder costs on gas retirements subsequent to 1915, and average costs per year for each class of unit for electric retirements since 1915.

Los Angeles Gas & Electric Corp. uses inventory records for large units and average costs for small items. On overhead wire systems, it uses present day costs revised to produce original cost.

San Joaquin Light & Power Corp. has valuation records and cost analyses available for a large part of its retirement.

Southern California Edison Co. Ltd. uses valuations and cost analyses for all large plants and lines, original cost obtained from book analyses for smaller plants and lines not covered by valuations or analyses, and average yearly cost for distribution capital.

Interpretation of the Classification of Accounts

This committee has given considerable thought during the past year to the preparation of a booklet to explain in considerable detail what is intended to be included in each fixed capital account of the California Railroad Commission classification of accounts. It is apparent that the interpretations of a good many accounts vary with the individual company. It is equally evident that the text of some of the accounts is indefinite enough to permit of considerable variance. Such an interpretation would not only promote uniformity among the various companies, but it would automatically answer a great many questions which are being answered verbally from day to day and not always with the same answer each time. The preparation of this text, however, is a work of such magnitude that it may well be given more time and thought than is available this year. It is hoped that further discussion at the annual meeting will be of considerable assistance to the incoming committee.

Advertising Publicity Section[1]

The Advertising Publicity Section this year conducted round-table discussions on topics of general interest, holding one joint meeting with the corresponding section of the Pacific Coast Gas Association.

THE activities of the Advertising Publicity Section this year have involved three departures from the plan of operation followed by the section during the past few years. The first of these is the holding of its meetings separately, instead of in conjunction with those of the Commercial Section; the second is the holding of a joint meeting with the Advertising-Publicity Section of the Pacific Coast Gas Association; and the third is in the type of program carried out at the section meetings.

The separate meeting policy was decided upon for the reason that it was felt that meetings held concurrently with the Commercial Section tended somewhat to divide the attention of members interested in both commercial and advertising matters.

The joint meeting with the similar section of the Gas Association was felt to be a desirable and advantageous move, especially in these times, because of overlapping membership from the dual companies, and of the fundamentally similar interests of all public utility advertising and publicity men.

The change in the type of program carried out at the section's sessions came in the general meeting following the disposal of business. Instead of having outside speakers, round-table discussions were conducted on topics of current interest and importance to advertising and publicity men of the industry. Each topic was assigned to a discussion leader who first presented briefly his own views and comments on the topic and then guided general discussion from the floor. This method developed intense interest and widespread participation by those present, and brought out a variety of opinions and angles on each topic. Whenever possible, conclusions were arrived at, which crystallized the sentiment of the group.

The following list gives an idea of the scope and pertinence of the topics under discussion by the section: "Of What Value Are Public Utility House Organs?"; "Should Newspaper Attacks Be Answered or Ignored?"; "Are Public Utility Advertising Rates in the Daily Newspapers Too High?"; "Would Concerted Action Be Desirable?"; "How the Advertising Department Can Help Secure Dealer Cooperation"; "How Far Should Advertising Go in Criticizing Competitive Fuels and Appliances?"; "Has the Radio a Place in the Advertising Program of a Public Utility?"

All of these three features of the section's activities proved to be very beneficial, from the standpoint of both attendance and interest.

The usual exchange of advertising proof among member companies was continued this year, and in addition, during the latter part of the year, a similar exchange with member companies of the P.C.G.A. was under trial to determine the practicability of making this practice a permanent feature of the section's activities.

The first meeting of the section was held in San Francisco, October 30; the second, in Los Angeles (the joint meeting

[1] E. P. Ramsay, Los Angeles Gas and Electric Corporation, chairman; F. M. Raymond, San Diego Consolidated Gas & Electric Company, vice-chairman; Miss Ella Russell, Coast Counties Gas & Electric Company, secretary.
California Electrical Bureau: V. W. Hartley.
Electrical West: Wm. A. Cyr, J. W. Otterson, G. C. Tenney.
General Electric Company: Fred Garrison.
Graybar Electric Company: Warren Simmons.
Los Angeles Gas and Electric Corporation: D. L. Scott.
McGraw-Hill Company: W. C. Heston.
Pacific Coast Electrical Association: K. I. Dazey.
Pacific Gas and Electric Company: A. M. Frost, J. C. Jordan, A. C. Joy, F. S. Myrtle.
San Joaquin Light & Power Corporation: S. W. Green.
Southern California Edison Company Ltd.: W. L. Frost, R. G. Kenyon, R. E. Smith.
The Southern Sierras Power Company: J. R. Gabbert.
Standard Management and Operating Corporation: Miss Alma Freeburg.
Valley Electrical Supply Company: J. U. Berry.
Westinghouse Electric & Manufacturing Company: E. W. Nilsson.

with the P.C.G.A. section) on February 18; and a third on April 15, in San Francisco. A session of the section is planned also for the convention, as well as some form of section contribution to the general sessions.

Commercial Section[1]

GENERAL BUREAU REPORTS[2]

The work of the general bureau is covered in the reports of its subcommittees, which follow.

THE first meeting of the customer relations committee which was held on the occasion of the Los Angeles conclave in October brought forth extended discussion as to whether or not the general bureau activity for the year should take the form of an essay contest. Members were unanimous in the opinion that should another such contest be conducted, the subject would have to be one which offered exceptional appeal. By reason of the unusual public interest that has attached to the question of the government ownership of public utilities, it was decided that here was a subject which would attract the attention of member company employees to a high degree. It was, therefore, decided that this would be the subject of the contest and employees information pamphlet No. 3 was chosen as a manual to be used as the principal text.

The contest itself is being directed by the employee information committee of which D. L. Scott is the chairman. With a view to developing interest among not only the employees of member companies but the executives as well, Miss Clarita Scott was chosen as contest director. It should be said at this point that Miss Scott has performed a masterly service and that she is to be highly commended for the splendid work that she has carried out. While we are now in the midst of the contest, indications point definitely toward employee participation well in advance of anything that has ever been heretofore attained.

First prize	$100
Second prize	75
Third prize	50
Fourth prize	25
Next 10 prizes, each	15
Next 25 prizes, each	10

After the prize winning papers shall have been excluded, prizes of $5 each will be awarded to 50 of those remaining by a drawing, the sum total of prize money amounting to $900.

*Employees' Essay Contest**

The subject of "Government Ownership" has been chosen for this year's employees' essay contest, the usual prizes being offered by the Pacific Coast Electrical Association and by participating companies.

THE subject of "Government Ownership," based on the N.E.L.A Employee Information Manual of the same title, was handed to the essay contest committee by the general bureau—and the activities of the essay contest committee started at that point.

Conditions Governing Contest Trophy

The rules of the contest and the prizes offered are the same as those of last year, thirty-nine prizes being offered, with a total cash value of $900. This information was given in detail on blue registration blanks which were provided for all essay writers.

Inter-Company Contest Trophy

At the outset of the contest, Addison B. Day, president of the Association, provided a trophy to be given each year to the company which produces the greatest number of essays in proportion to its number of employees entitled to participate in the contest. The awarding of this trophy is to be governed by the following rules:

1. The trophy shall be awarded by the president of the P.C.E.A., at the time of the annual convention, to the company which has produced the greatest number of essays in proportion to the number of potential writers. The trophy shall be held by the winning company until the next annual convention, at which time it shall

Trophy offered by President Addison B. Day for the best company participation in the essay contest

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[1] Executive committee: Frank Weiss, chairman. H. N. Carroll, vice-chairman, G. T. Bigelow, R. J. Cordiner, H. M. Crawford, H. L. Harper, J. H. Jamison, W. C. McWhinney, A. F. Morairty, P. P. Pine, E. G. Stahl, Pierre Vinet.

[2] Lloyd Henley, San Joaquin Light & Power Corporation, chairman. Alfred May, San Diego Consolidated Gas & Electric Company, chairman customer relations committee. D. L. Scott, Los Angeles Gas and Electric Corporation, chairman employee information committee.
Arizona Edison Company: C. T. Yates.
Los Angeles Gas and Electric Corporation: Miss Clarita Scott.
Pacific Gas and Electric Company: Don C. Ray, R. D. Shea.
San Joaquin Light & Power Corporation: F. V. Boller, A. D. Church.
Southern California Edison Company Ltd.: C. B. Eaton, W. H. Fischer, Myron McNeal, R. E. Smith, A. B. Wollaber.
The Southern Sierras Power Company: A. G. Cage.
Vallejo Light & Power Company: Albert Casper.

* Report of subcommittee on essay contest, customer relations committee, general bureau, Commercial Section. Clarita Scott, chairman. J. S. Arnold, G. T. Bigelow, W. S. Boggs, A. D. Church, S. E. Davis, L. L. Hennessy, A. C. Joy, E. E. LaRue, Ella Russell, A. Shackelford, R. E. Smith, C. F. Stanley.

be awarded to the winning company for that year; and so on, indefinitely.

2. Potential writers shall be computed as follows: From the total number of employees at the time of the contest deduct the number considered ineligible to enter because of official position; also deduct the number of temporary employees, such as day laborers and persons employed temporarily; and further deduct the number, if any, of employees who do not speak or write English.

3. Combination companies are urged, whenever the subject is of a general nature, such as a public relations or customer relations theme, to encourage employees in other than electric and general departments also to enter the contest. In such cases, however, essays written by employees in other than electric and general departments will not be included in the computation to determine the extent of participation; nor will the employees of such departments be included in the base figure with which the number of essays is to be compared.

The Conduct of Contest

The contest has been under the management of a corps of very effective company contest directors. To these contest directors, and to the company executives has been sent a series of bulletins under the title of "The Director." This medium has served to maintain interest in the contest in all vital quarters, and as a vehicle for the interchange of opinion and methods.

The following is a detailed report of results in the companies in the competition for the trophy:

Company	Total Essays	Less Gas Dept. Essays	Employees	Percentages
Coast Counties G. & E. Co.	123	27	137	70.1
Los Angeles G. and E. Corp.	1,793	522	1,839	69.1
San Diego Cons. G. & E. Co.	527	85	682	64.8
Southern Sierras Power Co.	346	.....	597	58.0
Central Arizona L. & P. Co.	57	.....	207	28.0
San Joaquin L. & P. Corp.	289	17	1,282	21.2
So. Cal. Edison Co.	461	.....	3,889	11.8
Tucson G., E., L. & P. Co.	7	.....	124	5.6
Pacific G. and E. Co.	185	.....	7,983	2.3
Totals	3,788	651	16,740	330.9
Average % participation by companies				34.5
Average % participation by employees				18.7

By the above showings, the president's trophy was won by Coast Counties Gas & Electric Co., under the leadership of Miss Ella Russell, essay contest director.

The trophy will be awarded by Mr. Day at the time of the P.C.E.A. convention in Pasadena, in June of this year.

The total number of essays submitted for 1932 was 3,785 compared with 1,747 submitted last year. This means a gain of 2,038.

Winners of Prizes

The winners of the 39 merit prizes were as follows:

First Prize, $100 Cash—

Howard A. Sullivan, advertising department, San Joaquin Light & Power Corp.

Second Prize, $75 Cash—

Frieda Redman, Lancaster office, Southern California Edison Co.

Third Prize, $50 Cash—

Ethel A. Hall, investment department, Southern California Edison Co.

Fourth Prize, $25 Cash—

Paul L. Emerson, auditing department, Southern Sierras Power Co.

Next Ten Prizes, $15 Each—

Southern California Edison Co.: Prentis C. Hale, accounting department; James A. Meyers, Montebello office; Elsie Levy, accounting department.

Southern Sierras Power Co.: Marjory N. Bates, executive department; Leta E. Gilliland, treasury department; Violet Looney, Calexico office.

Los Angeles Gas and Electric Corp.: Guy Corfield, chemist; George M. Sadler, accounting department; Lyndon Thueson, bookkeeping department.

Central Arizona Light & Power Co.: Charles Dunn, Jr., engineering department.

Next Twenty-five Prizes, $10 Each—

Los Angeles Gas and Electric Corp.: Ashley Caswell Woody, electrical distribution department; Max E. Turner, gas distribution department; Warren W. King, bookkeeping department; Nathan S. Kuhn, new business department; Paul C. Kuntz, new business department; James F. Lewis, collection department.

Southern California Edison Co.: Leonard L. Lambuth, meter department; Marcella B. Ashley, commercial department; Edna Patterson, right-of-way department (coast division); Durant L. Danielson, Santa Barbara office; G. N. MacKinnon, distribution department (Long Beach).

Pacific Gas and Electric Co.: D. J. Fee, engineering department; Mrs. Beulah Brown, personnel department; M. A. L. Willson, publicity department; Agnes Barrell, publicity and advertising department.

San Diego Consolidated Gas & Electric Co.: A. V. Bryant, electric production, Station B; James H. Bach, record department; Mrs. Dorothy L. Hughes, stenographic department.

Southern Sierras Power Co.: Paul H. Yelton, Randsburg; Helen Rogers, rate department, Riverside.

Coast Counties Gas & Electric Co.: O. E. Fisher, accounting department; E. M. Brickley, sales department.

San Joaquin Light & Power Corp.: Frank C. Krasny, operating department; Lee R. Duncan, engineering department.

Tucson Gas, Electric Light & Power Co.: Mrs. Blanche H. Walker, accounting department.

Fifty $5 Prizes, by Lot—

Los Angeles Gas and Electric Corp.: Sherman Jefferies, J. H. Overland, H. N. Johnson, Ross Cerra, R. T. Hillhouse, Carlyle Wynn, P. J. Gray, W. H. O'Connor, J. H. Hill, T. B. Tittle, P. C. Dorland, S. E. Anderson, James E. Euwer, J. L. Hall, H. C. Green, Theo Hand, J. B. Curry, L. S. Griswold, C. C. Oehl, Leo Koch, W. E. Ludlow, E. N. Shield, Clark G. Stedman, Fred Haas, O. F. Adkins.

Southern California Edison Co.: F. G. Stone, Carl M. Sellman, Allen L. Laws, Mrs. Anne Glotzbach, B. W. Lane, Troy H. Jones, Myrtle Luella Douglass, William J. Jones.

Southern Sierras Power Co.: George A. Beck, John F. Russell, Lee Wallace, C. W. Hagerman, Bryant Weeks, Ralph Blake, P. H. Grow, Jessie McCreary.

San Diego Consolidated Gas & Electric Co.: A. J. Tait, L. R. Bowen, Tom Batty.

San Joaquin Light & Power Corp.: R. E. Curran, Julia Hannam.

Pacific Gas and Electric Co.: Dennis Russell, Frank Cheever.

Coast Counties Gas & Electric Co.: George Zuschin, H. B. McLaughlin.

Judges

The judges who so kindly gave their time and effort were:

S. W. Murray, Westinghouse Electric Supply Co.
Harry C. Goldrick, Graybar Electric Co.
Victor Hartley, Pacific Coast Electrical Assn.
F. B. Nightingale, General Electric Supply Corp.

Pacific Coast Electrical Assn. is deeply indebted to these gentlemen for their fine service, and the contest director is especially under obligation.

Acknowledgment

The splendid response to the call for essays has been due to the interest and cooperation of the company contest directors and company executives, and to the competition for the president's trophy. To all those who have given their time and support to the successful completion of this contest, the contest director is deeply grateful.

LIGHTING BUREAU REPORTS[2]

*Some Sales Arguments for Better Commercial Lighting — Prepared for Those Who Do and Those Who Should Sell Good Lighting**

The report of the commercial lighting committee this year has been prepared in the form of a booklet designed to aid the electrical contractor to obtain contracts for adequate wiring for lighting on commercial jobs. The text is given herewith.

THIS booklet has been prepared with the object in view of aiding the electrical contractor to obtain contracts for adequate wiring for the lighting of commercial jobs. Its chapters have been designed with the purpose of helping the electrical contractor sell a good job of wiring for illumination purposes, which will not only be profitable to himself but satisfactory and profitable to the business man whom he serves.

The lighting customer is the keystone to the arch of the electrical contracting business. Therefore, the electrical contractor is in the best position at all times to sell and install, with profit to himself and convenience to his customer, *a complete wiring job.*

It is a well-known fact that electric illumination is one of the best methods of advertising. The electrical contractor should at all times advance this fact when dealing with the business man in connection with wiring for lighting jobs.

This booklet offers suggestions, which, if followed, will enable the contractor to obtain not only information, but the services of experts of the electrical industry, who will aid in selling adequate illumination for all business purposes.

This pamphlet is intended to inspire the use of every available faculty and the ingenuity that is a part of us, to further better illumination.

What the Lighting Business Means and Could Mean to the Contractor

With a few exceptions (large centers of population) the lighting business, both in the home and commercial, is practically beyond the knowledge and control of the contractor, due to several facts that for years have kept this fine field from paying him an excellent profit. First, the price per outlet used extensively throughout the country is made without thought of the consumer's needs or desires; and second, the contractor has been unwilling to study lighting and to present it with a clear, concise effort of salesmanship.

The lighting business could mean a close contact with business and professional men, removing the contractor from the mechanic's class. To engage in it would give him the satisfaction of selling a service of merit and would improve his worth to the community. In fact, his associations in contacting and selling the story of lighting would round out his life, so that he could and would appreciate his civic standing in the community. Good lighting can be sold every day in the year and provides an enormous field in which to work. It is sold for results, not a price—which reduces competition to a minimum. The periodical change in efficiency of lamps and reflectors does not allow saturation. To obtain results, equipment sold must be the best—standard quality and standard prices.

Who Are Prospective Buyers of Good Lighting at Present?

Where to sell good lighting? Sell good lighting to anyone who has long hours of night work—the longer the hours, the better the prospect. All-night restaurants, sandwich stands, drugstores, markets, etc., need good lighting. Sell it to anyone who does fine detail work—jewelers, printers, etc. Sell it to anyone displaying a competitive line of merchandise. Drugstores are a fine example. At any drugstore you can buy any standard product at the same price as at the store of the neighboring druggist. Which one is doing the business? The well lighted store, of course.

Sell it to all retail establishments, such as dry-goods stores, cigar stores, hardware stores, restaurants, jewelry stores, radio stores, confectionery stores, bakery shops, beauty parlors, service stations, schools and grounds, athletic fields, theaters, office buildings, golf-practice fairways, lodgerooms, clubrooms, reading rooms, libraries, art galleries, banks and all financial institutions, hotels, roadhouses, hospitals, churches, courts and to prospects for floodlighting and illumination for their protection against burglary.

Sell to all manufacturing establishments and places of business, such as machine shops, steelmills, tire-manufacturing plants, automobile-assembling plants, garages, sawmills and woodworking establishments of all kinds, and iron foundries. In connection with manufacturing plants, do not overlook the yards of such plants. Oil fields, oil foundries, oil storage plants, oil delivery stations; tileworks; textile plants; railroad shops and round houses, which are usually very poorly illuminated; steamship terminals, wharves and fishing piers; refrigerating plants, storage warehouses; markets, wholesale and retail; laundries; bakeries; poultry ranches; all kinds of packing plants, including fruits, vegetables, etc.; canneries; and all kinds of manufacturing plants—all are lighting prospects.

What Happens When You Sell a Poor Job of Lighting

Little or no profit for the contractor.
Service switch and distribution cabinets too small.
Not enough circuits.
Copper too small—voltage drop and power loss.
Lamps not efficient.
Results poor. Can't give results in foot-candles, estimated.
Shadows.
Consumer has paid for something he did not get; dissatisfaction with results and with contractor.
Loss of prestige.
No provision for future expansion or modernization.

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[2] G. M. Rankin, Southern California Edison Company Ltd, chairman.
Baker & Prussia: Clark Baker, Sr.
Benjamin Electric Manufacturing Company: C. O. Martin.
Coast Counties Gas & Electric Company: R. C. Dalton.
Curtis Lighting Inc.: J. E. Lauderdale.
Edison Lamp Works: L. G. Gianini.
Edwin F. Guth Company: L. A. Hobbs.
General Electric Company: R. A. Buckby, W. E. Carlson, L. A. Gates, K. M. Koch, E. P. Markee, D. J. Prudhomme.
General Electric Supply Company: F. B. Nightingale.
Graybar Company: C. L. Huyck.
Holophane Company: Frank Hansen.
Los Angeles Gas and Electric Corporation: R. A. Crosby, Ann Pennington, George Riley, H. B. Wells.
Pacific Gas and Electric Company: W. P. Bear, W. S. Hanbridge.
San Joaquin Light & Power Corporation: J. E. Hammond.
Southern California Edison Company Ltd.: C. M. Bliven, W. G. Blossom, C. W. Koiner, D. F. Collier, C. N. Elgan, W. P. Graef, N. Hearne, Jr., C. E. Hewes, C. G. Lindsay, L. S. Lothridge, W. J. Moreland, M. L. Saunders, A. I. Whitehead.
The Southern Sierras Power Company: S. A. Cundiff.
Valley Electrical Supply Company: Carl Wolf.
Westinghouse Electric & Manufacturing Company: L. F. Church, C. E. Johnson, L. M. Watson, F. J. Wellhouse.
Westinghouse Lamp Company: C. E. Thompson.
Westinghouse Supply Company: Scott Betts, S. H. Simonson.

* Report of the commercial lighting committee, lighting bureau, Commercial Section. R. A. Crosby, chairman. R. A. Buckby, E. F. Church, S. A. Cundiff, L. G. Gianini, W. S. Hanbridge, Frank Hansen, L. A. Hobbs, C. W. Koiner, C. G. Lindsay, F. B. Nightingale, W. K. Turner.

Lack of confidence of customer in ability of contractor, resulting in *no comeback business* (free of selling costs), which is the *contractor's velvet.*

What Happens With a Good Job

A reasonable profit for the contractor.
Ample provision for expansion.
No voltage drop or power loss.
A sense of well-being; you have created something.
Advertising for your company.
A boost for you or your company in the community.
A satisfied customer.
A more rapid stock turnover, at a minimum merchandising cost.

What Good Lighting Means to the Average Small Business Man

In his store—
- A clean store.
- A chance for better and more pleasing display of merchandise.
- More inviting from the outside.
- A finer selection of color and color matching.
- Reflects the management.

In his windows—
- One of the best advertising mediums.
- Secures and holds attention.
- Stops people on sidewalk.
- Ties-in with other advertising.
- Enables one to display merchandise naturally and effectively.

In office—
- Improved efficiency and morale.
- Reflects personality of store.

In plant—
- Higher efficiency.
- Increased production.
- Personal safety.

The small merchant should use good lighting because good lighting is good business. The smaller the establishment, the more it has to compete with other establishments and the wider its field of competition. It competes with the individual department of the larger department stores, with the neighborhood stores carrying the same line, and with the downtown specialty shop as well. Good lighting enables the small individual business to display its wares, all of them, to their best advantage. It makes its windows outstanding and attracts the attention of the passerby. They remind him of something that he has needed for a long time, and he enters to secure it. Once in the store, he sees other things that he remembers he should have, and the 10c. sale is turned into a dollar one. But what has this to do with you? Simply this. By showing the merchant the benefits of good lighting, you can sell him a *real job,* thus doing him a favor and making him a regular customer. You profit and so does he.

When should good lighting be sold? Right now there are dozens and dozens of establishments in your neighborhood which *need* good lighting. They may not know it, but they are suffering from the want of it. A little good salesmanship will enable them to see that they need it. You know yourself that they do. Show them what it will do for them and you will have done them a favor and have secured for yourself a nice piece of business. They aren't going to call you up and ask you to come in and tell them all about it, but they are mighty good listeners when they realize that you know what you are talking about.

The Importance of Good Lighting

In the Small Store—

Good lighting, which is of obvious value to any store, large or small, is comparatively of greater importance to the small store. A proportionately higher expenditure for illumination is justified because of the greater benefits which the small store derives from high standards of illumination.

The smaller store lacks the impressiveness and consequent prestige which mere size gives; it is not as well known or generally discussed; it depends to a greater extent on the trade of transients; more of the trade is derived from people who are suddenly reminded of something they need; and finally, because of either location or lack of size, it may be more easily missed. Good lighting has proven its ability to aid in overcoming these handicaps.

Impressiveness of lighting and decoration can be substituted for that of size. With built-in lighting as an integral part of the interior structure, a strikingly beautiful and attractive picture is created which cannot help but impress the casual or regular customer. Properly planned, such lighting will often more than meet utilitarian requirements.

Even for the older stores, modern lighting equipment offers great modernizing possibilities. Simply replacing the old fixtures with the modern type gives an immediate impression of progressiveness. If the store suffers in appearance because of a very low ceiling or an unusually high ceiling, pleasing changes in general appearance may be made by merely substituting different lighting fixtures. Semi-indirect fixtures cause the interior to take greater height, while totally indirect fixtures will provide the illusion of a lower ceiling. In either case the ceiling should be of some light color which reflects light well. If the store is narrow, say 16 to 20 ft. wide, substituting two rows of ceiling fixtures for the conventional one has the surprising effect of making the store appear twice as wide. The same result may be accomplished with totally indirect fixtures, if the ceiling is a good reflector. In doing this, care should be taken to change somewhat the ordinary spacing. Instead of placing the two rows so that the distance from the wall to the first row is half the distance between the rows, the relationship should be changed to one to three. This is also desirable from an illumination standpoint, in that it prevents customers from throwing a shadow onto the counters, generally running parallel and close to the walls.

The small, well-lighted store, brightly contrasting with the adjacent ones and even with the larger stores, will attract attention, will stand out, and by virtue of the drawing power of light, will pull in customers. The well-lighted store, enabling shoppers to see clearly and distinctly and to appraise the articles on display, cannot help but eliminate distrust and suspicion. By reducing the customer's indecision, sales will be increased as well as speeded.

The added life, luster and sparkle imparted to the wares by high-level lighting, enhances apparent values and makes them appear more desirable. Automobile manufacturers and sellers show their appreciation of this fact by their use of as many chromium trimmings as possible, with their attendant glitter.

Returned goods will be reduced to a minimum in the store lighted in such a manner as to permit the customer to see exactly what is bought at the time of purchase—not some time later.

Finally, there are the many purely psychological benefits of modern illumination.

Take, for example, the case of the store selling food stuffs —a bakery, grocery, or delicatessen shop. It is a common human trait to seek out such stores for their cleanliness, the freshness of their wares, and for the assurance of rapid turnover with attendant low prices. A brightly lighted store presupposes all of these. In such a store, dirt cannot exist—

it would be too obvious. Brightness creates the impression of freshness as well as rapid turnover.

In the same way that a bright sunny day puts us all in the best of spirits, so does a cheerfully lighted store. In the case of the customer, this means less sales resistance. In the case of the clerks, this makes for happier and more courteous attention to the trade with its constant effect on increased sales.

In the Show Window

What has been said about the value of good lighting to the small merchant in his store applies with even greater force in the case of his show windows.

In order that the show window may yield maximum returns, it must satisfy the following requirements:

1. The goods on display must be seen by the greatest possible number of people.

2. The display must create the desire to enter the store, if not with the intention of buying, at least with the desire for further investigation.

To satisfy the first requirement, the foot traffic passing by the store must be high, the show window and its displays must have attention-compelling value, and competing attractions must be overcome.

The attracting power of light on human beings is well known. Tests conducted in different cities have shown that bright or artistically lighted show windows will materially increase the amount of foot traffic passing by the store having such windows, at the expense of the other side of the street or even other streets. When the small store is located on the side of the street opposite large and well-known department stores, the necessity for outstanding displays and lighting is even greater, because the natural tendency of the public will be to walk on the side of the well-known store. To overcome this, it may even be necessary for the owner of the small store to join with his neighboring stores in some sort of a cooperative action in so far as show-window lighting is concerned. A series of small stores more brightly illuminated than the large store across the street will divert many shoppers from their normal course.

Not only will the well-lighted show window draw foot traffic, but it will cause a much higher percentage of passersby to stop and look at the display than normally. This statement has been proven by numerous tests. In the daytime, too, these tests have shown that a higher percentage of the foot traffic stops to look when a reasonable standard of artificial lighting is employed.

In the well-lighted window, people see more, and more quickly, too. It can be readily demonstrated that a person examining a display for a given interval of time will, other things being equal, see more of the display in a brightly lighted than in a dimly lighted window. Part of this is due to the physiological fact that the eye can see more quickly (respond with snapshot quickness instead of time-exposure response) and partly to the psychological fact that higher light levels are stimulating to action.

From the above, it is evident that light can play a dominant part in insuring that the greatest possible number of people will see the merchant's window display. It will also aid in creating the desire to enter the store in order to examine the articles more closely or actually to make purchases.

The same reasoning given under the head of store lighting applies to the show window.

In the Small Shop—

In general, the testimonials quoted proving the value of good illumination in industry are from large industrial enterprises. This is because such testimonials are of national circulation and the larger industrials are known in all sections of the nation, and not because good artificial illumination does not produce equal or greater benefits in the smaller shops and plants.

As a matter of fact, casual analysis shows that, whatever the possibilities are of good lighting in the large mechanized plants using much automatic equipment, these possibilities are much greater in the smaller shop where individual performance counts for so much.

The smaller the shop, on the average, the greater are the demands on hand craftsmanship, and this in turn can only be as good as the craftsman's vision will permit. Keenness and speed of vision, and likewise the quality and quantity per worker, are dependent upon the available standards of illumination.

This applies to the small auto repair shop, the small laundry, job-printing house, clothing plant or alteration shop run by any retail clothing establishment. All of them obviously demand more all-around work from the employee; he must use, and therefore hunt and select, a greater variety of tools; he must refer to blueprints more frequently, he is called on to do jobs making greater demand on the eyes than his brother worker in the large automatic shops. Obviously good lighting is, therefore, much more essential.

The safety of the employee in the small shop is more dependent upon the individual's vigilance than in the larger one, with its safety engineer and elaborate safety measures and guards.

All of this calls for higher standards of illumination in the small shop, and yet we find the larger plants in Detroit and Cleveland extremely well lighted, while our small shops are depressingly lighted. This condition exists only because the operators of the large plant can very easily measure the value of lighting on employee efficiency, which is not the case in the small shop.

General Benefits Derived From Good Lighting

As in the case of the office, there are many psychological benefits to be derived from good illumination, all making for lower operating costs.

In a dimly lighted shop a feeling of sleepiness pervades. It lacks the wideawake atmosphere making for maximum efficiency. The dimly lighted or glaringly lighted shop is depressing and the management pays for it in lowered employee morale.

In the smaller offices and organizations, a much closer feeling exists between employer and employee than in the larger impersonal organizations. The employer is more genuinely interested in the welfare of his workers. His daily contact with them cannot help but have its effect.

He is, therefore, interested in anything reasonable which will reduce human depreciation. Eyesight, more than any other human faculty, is subject to depreciation from prolonged office work, even at its best. Good lighting will, more than any other factor, ameliorate the effects of continuous close eyework. The employer may not be able to afford the rental of offices with good natural lighting conditions—particularly the smaller employer. He can, however, always afford to secure reasonably satisfactory artificial lighting facilities.

This is true, because the difference in cost between the poorest standard used anywhere and reasonable lighting will be far more than offset by the increase in his employees' efficiency, even during their years of maximum productiveness.

Errors will be reduced. Numerous unbiased tests have shown a surprising relationship between the number of errors made by those carrying on close eyework and the kind of illumination under which they work.

These tests are amply borne out by the observations of managers of offices which have replaced obsolete, inadequate artificial-lighting equipment with modern illumination facilities.

They have noted particularly striking results toward the end of the day. The workers' eyes are already tired and their supply of nervous energy is low, so that their vision is doubly sensitive to good lighting. Conversely, satisfactory illumination produces obviously beneficial results.

Benefits of this type are greatest during the winter months when artificial light must be used many hours during the day and often into the night, because of usual added seasonal activity. Good lighting then becomes a sort of insurance, permitting of reasonable employee efficiency during the winter overtime periods.

Not only does it cut office costs by reducing mistakes to a minimum, but it also makes it possible for each employee to turn out a maximum of work. Good lighting permits the worker to operate swiftly by eliminating any hindrance to quick, easy vision.

Tests have shown that a normal "fresh" employee can turn out more work with good than with indifferent illumination, because his eyes see more quickly. Employees stay fresh longer with good light. The retarding influence of headaches induced by eyestrain is eliminated.

When a worker feels his eyes burn or smart or his head aches or he feels a dull pain, the natural reaction is to hold back, to try to "save" himself.

How to Sell a Good Job of Lighting

There is but one way to *sell* a lighting job. Show your prospect just what good lighting will do for him. Show him how it attracts attention to his windows; how it converts shoppers into buyers; how it enables him actually to display his merchandise to best advantage; how it reduces the quantity of returned merchandise; and how it makes his establishment stand out from the mediocre places of business in his community. Show him that good lighting is advertising and operating expense combined. Show him how it reduces spoilage, soiled goods, unnecessary handling, delayed decisions, etc. These are the things that your lighting prospect must know.

There is no rule-of-thumb method of lighting any installation. Local conditions will dictate. The central station, the legitimate manufacturer's representative, and even the jobber's salesman, not to mention the lamp companies, are in a position to give you reliable information. The one important thing may be summarized as follows: "Find out what a man needs. Find out how to satisfy this need. Show him that he needs it, and you have made a sale." The jeweler on his repair bench must see more quickly and more accurately than the blacksmith at his forge. The dentist and the auctioneer each has his individual problems, which is true of every other merchant.

However, there are some rules we must observe regardless of the case. Bare lamps, without shades or reflectors, are never efficient and are actually detrimental to vision. The choice of reflectors and their mounting height and spacing are the heart of the job. Your experience, combined with that of your jobber's salesman, your manufacturer's representative, and your central station lighting man, will assure you and your customer a satisfactory installation.

The following paragraphs discuss rather briefly some of the types of lighting; that is, direct, semi-indirect, and totally indirect, and their normal usage. The commercial Red Seal specifications distributed by the Pacific Coast Electrical Bureau, a tabulation of which you will find contained herein, will insure adequate wiring, and adequate wiring and good lighting go hand in hand.

Choice of Lighting System

As previously mentioned, there are three general systems of illumination classified according to the manner in which the light is distributed:

1. Direct lighting
2. Indirect lighting
3. Semi-indirect lighting

Direct lighting systems employ fixtures which send the greater portion of light direct to the surfaces to be illuminated. Both open reflectors and inclosing glassware come under this heading. Inclosing glassware is generally applicable and desirable, since it diffuses the direct rays of the lamp, improves the diffusion somewhat, and greatly improves the appearance of the lighted room.

Totally indirect lighting utilizes the ceiling and upper sidewalls for the redirection and diffusion of all the light emitted by the luminaires. Since the ceiling acts as the light source, with the maximum of distribution directly downward, glare from the unit is avoided and shadows are soft, but for a given foot-candlage on horizontal surfaces, there is usually somewhat less illumination on vertical surfaces than with other systems.

PACIFIC COAST ELECTRICAL BUREAU RED SEAL WIRING STANDARDS FOR COMMERCIAL BUILDINGS ONLY—(NOT INDUSTRIAL, RESIDENCE, CHURCH OR THEATER)

		Wattage per sq. ft.	Convenience and special outlets
All commercial buildings (except those below)		3	
Auditoriums		2	
Basements		1	
Banking rooms	general illumination	3	
	cage illumination in addition to above	4	
Baths		1	
Corridors (except hotels and schools)		1	
Dance halls		2	
Drafting rooms		5	
Elevator cages		1,000 pair	
Exits		50 each	
Fire escapes		50 each	
Garages	main entry floor	2	
	aisles and ramps	½	
	storage space	...	
	wash racks	1,500 each	
Halls (except hotels and schools)		1	
Hospitals	wards and private rooms	1	
	operating rooms	10	
	laboratories	5	
Hotels	dining rooms	2	
	bedrooms, two convenience outlets	1½	2
	bedrooms, three convenience outlets	1	3
	halls, passage and corridors	½	
Lavatories		1	
Office buildings		3	1 per 100 sq. ft. 1 per 400 sq. ft.
Passageways (except hotels and schools)		1	
Schools	drawing and artrooms	5	
	corridors and stairs	2	
	toilets and washrooms	1	
Stations	waiting rooms	2	
	restrooms	2	
	storage	2	
Stairways (except schools)		100 each	
Stores	interior	3	1 per column 1 per 400 sq. ft.
	show windows	150 foot	1 per 50 sq. ft.
	signs	1,500 each	1 per 10 ft. glass
	spots and floods	300 each	2 per 10 ft. glass 1 each 10 ft. glass (additional)
	show cases	2,000-50 ft.	1 per column

1. Spacing of ceiling outlets not to exceed:
   (a) 1½ times ceiling height (except halls, corridors and garage storage space).
   (b) 225 sq. ft. of floor space (except 18 ft. ceilings).
   (c) 25 ft. bay when ceiling height is 18 ft. or more.
   (d) 20 ft. in halls and corridors.
   (e) as desired in garage storage spaces.
2. Convenience outlets not to exceed:
   (a) 8 per circuit (except for showcases).
   (b) 3 per circuit (installed for showcases).
3. Watts per circuit, 1,000 (except signs and washracks).
4. Wire No. 12 minimum 100 ft. or less—No. 10, all over 100 ft., except stairs, fire escapes and exits.
5. Voltage drop—not to exceed 2% in services, feeders and circuits over 1,000 watts.

Semi-indirect lighting furnishes a means of combining the features of direct and indirect systems. With a correctly designed bowl of white glass, brightness of the unit is low enough so that eye fatigue is avoided, and sufficient direct light is emitted so that the proper degree of vertical illumination is obtained, and soft or graded shadows are produced.

The individual characteristics of the room to be lighted are important factors in the selection of a lighting system. The presence of large quantities of dust often discourage even a

consideration of indirect or semi-indirect systems, unless these units are inclosed at the top. The dark tone of the walls and ceilings also often precludes the use of any other system of direct lighting. Cost and efficiency are factors which may limit the choice, although the present tendency, particularly in the more specialized branches, is to make good lighting the first consideration. It may also be mentioned that the liberal use of paint can hardly be too strongly recommended.

In office and public-building lighting, the system should, of course, be of good appearance and in harmonious relation with the decorative or architectural features of the surroundings. Semi-indirect and inclosing fixtures lend themselves most readily to these classes of service, if the color of the ceiling and walls permits their use. It should always be borne in mind that such fixtures, to be satisfactory as to glare, must be selected with care. Totally indirect units are practically certain to be satisfactory from the glare standpoint.

When the installation is such that a decorative fixture is essential, it should always be remembered that the primary purpose of the fixture is to provide light of sufficient quality and quantity to meet the visual requirements. Fixtures, no matter how beautiful or artistic, are unacceptable unless the lighting requirements are satisfied. Fixture design should and easily can incorporate highly artistic motifs, with an equally high regard for the function of the fixtures as efficient lighting devices.

When asked to figure on a wiring job for lighting, don't try to convince your customer that he can get along without some of the lights he needs and wants, just to underbid your fellow contractor, who is competing with you for the job. Every job you get in this way is costing you something. To do so is very bad practice and results in a dissatisfied customer and in little profit for those who practice it.

Know good illumination, and sell it to your prospect, particularly when he comes into your place of business and gives you an opportunity to do so, as he does when he requests you to bid on his wiring job. If you encourage inadequate wiring, your customer will condemn you at some future time and will never come back when he needs a good job for wiring; whereas, if you sell him an adequate job of wiring, he is your customer ever afterward. Therefore, do not overlook the opportunity of suggesting to him those outlets for all the things he is likely to use in connection with his business. If you find that you cannot sell him, call to your assistance those at your disposal, who will help you. The electrical industry has provided such assistance as you may need. Learn to work with others. Cooperation will bring results where singlehanded efforts fail. You have been provided with all the necessary personnel and equipment required to sell good lighting jobs at all times. Use it.

Don't overlook the fact that selling is one of the largest items, or should be, in business costs, and usually amounts to about 12 or 13 per cent of sales. Therefore, contractors cannot afford to overlook the necessity of doing a good selling job.

When selling your customer, emphasize the necessity for illuminating his storefront to attract attention. He pays big rent to be on the main street. If he does not light up in an attractive way he might just as well be in a back alley. Most merchants know this, except some electrical contractors, who should set a good example by proper lighting of their own places of business, or workshops.

There is an electric shop in Dallas, Texas, known as "The Store Without a Window." The whole store is a window, and from the sidewalk the beautifully decorated and well-lit interior is visible through the solid glass store front. It is a splendid example to the rest of the merchants. When we have sold ourselves a good job of lighting, it will be easy to sell our neighbors and fellow business men.

It has been found that people react to two appeals—logical and emotional, and inasmuch as their emotions can be appealed to, selling cannot be made an exact science. We should not try to sell people more than they should buy, but we certainly should try to sell them what they want and what they should have in the way of a finished job of wiring for illumination.

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*Educational Lighting**

The educational lighting committee this year devoted its energies to the presentation of a program on home lighting before member company employees and citizen's organizations.

THIS year the educational lighting committee devoted its energies to the presentation of a program for member companies' employees on the subject of home lighting, with demonstrations. The object of these talks was:

1. For the enlightenment of the employee.
2. To tie in with the work of those power company employees now taking the Edison Lamp Works home lighting course.
3. To lead up to the N.E.L.A. three-year home lighting sales program, just now being presented to the member companies.

In addition to the regular committee personnel, F. S. Curran, Pacific Gas and Electric Co., San Francisco, and W. J. Moreland, Southern California Edison Co., Los Angeles, lent most valuable aid as the lectures were presented to their respective companies.

The companies which availed themselves of the talks were:

Company	No. of District Offices	Attendance
Pacific Gas and Electric Co.	11	556
Southern California Edison Co.	17	1,200
Coast Counties Gas & Electric Co.	2	165
San Joaquin Light & Power Corp.	1	60
Los Angeles Gas and Electric Corp.	4	440
Total	35	2,421

In addition to these addresses, this committee gave home and general lighting talks to the following:

		Attendance
Advertising Club	Stockton	40
Advertising Club	Sacramento	55
Engineers Club	Stockton	35
Purchasing Agents Club	Oakland	35
Soroptimist Club	Los Angeles	75
Kiwanis Club	Los Angeles	240
Lions Club	Redlands	90
Kiwanis Club	Glendale	150
Holy Name Central High School	Oakland	160
Total—Ten clubs and schools	Six towns	880

The educational lighting committee presented three lighting subjects for the third commercial conclave which was held at Santa Cruz.

A Highway Lighting Program, by William P. Bear.

What Constitutes a Power Company Lighting Department, by George C. Tenney.

What the Educational Lighting Committee Has Been Telling Power Company Employees. by Clark Baker, Sr.

The budget for the year was $500; expenses were $484.21.

* Report of educational lighting committee, lighting bureau, Commercial Section. Clark Baker, Sr., chairman. W. G. Blossom, Walter Carlson, C. N. Elgan, L. G. Gianini, W. P. Graef, C. L. Huyck, F. B. Nightingale, S. H. Simonson.

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*Industrial Lighting**

The industrial lighting committee, after a careful study of the minimum commercial specifications adopted two years ago by the commercial lighting committee, as

* Report of the industrial lighting committee, lighting bureau, Commercial Section. C. O. Martin, chairman. R. A. Crosby, vice-chairman. H. C. Barnard, U. L. Beh, J. E. Hammond, V. W. Hartley, N. M. Hope, C. L. Huyck, M. L. Saunders.

well as further collaboration with architects, engineers and inspection authorities, has prepared a set of minimum specifications for industrial structures which it presents as its contribution to this year's activities.

LIGHTING demands have advanced in recent years to such an extent that engineers are encountering many owners of buildings who are unable to secure desirable levels of illumination without incurring large expenditures in rewiring. Quite frequently, this occurs even in new buildings which, because of their compliance with the National Electrical Code and local ordinance, meet all safety requirements and yet lack the wiring capacity for adequate lighting.

This situation in the commercial field was met by the commercial lighting committee of the Pacific Coast Electrical Assn., which prepared, in collaboration with representative authorities, a set of minimum specifications to provide adequate wiring for the proper illumination of commercial structures. These, after two years' use in the state of California, have been found reasonable and effective. The industrial lighting committee of the association, after a careful study of the above and after further collaboration with architects, engineers and inspection authorities, has prepared and now submits, as its contribution to this year's activities of the lighting bureau, a set of minimum specifications for industrial structures as companion specifications to the commercial.

It is recommended, if these specifications meet with the approval of the association, that early steps be taken to print them into permanent pamphlet form of A.I.A. size and that means be devised for their effective distribution among engineers, architects and others interested in their contents. In this connection, it should be added that no attempt was made, in the preparation of these specifications, to interpose any arguments in the way of justification for the requirements or of the advantages to be gained in their use. It is recognized that such arguments might be effective in furthering the acceptance of the specifications. There is a question, however, whether these arguments should be made a part of the specifications (in a separate column, perhaps), or whether they should be used only in the campaign of distribution. The answer to this will be left to the discretion of the association.

Minimum Specifications For Adequate Wiring of Lighting Circuits in Industrial Structures[1]

PREPARED BY
INDUSTRIAL LIGHTING COMMITTEE
PACIFIC COAST ELECTRICAL ASSOCIATION

Introduction

LIGHTING demands have advanced in recent years to such an extent that engineers are encountering many owners of buildings who are unable to secure desirable levels of illumination without incurring large expenditures in rewiring. Quite frequently, this occurs even in new buildings which because of their compliance with the National Electrical Code and local ordinance, meet all safety requirements and yet lack the wiring capacity for adequate lighting.

This situation in the commercial field was met by the commercial lighting committee of the Pacific Coast Electrical Association, which prepared, in collaboration with representative authorities, a set of minimum specifications to provide adequate wiring for the proper illumination of commercial structures. These, after two years use in the state of California, have been found reasonable and effective. The industrial lighting committee of the association, after a careful study of the above and after further collaboration with architects, engineers and inspection authorities, has prepared and is presenting, herewith, a set of minimum specifications for industrial structures as companion specifications to the commercial. Because of still further advances in lighting practice, which are certain to come, it is probable that the requirements herein set forth will need revision at some future time.

Architects and engineers, who find it desirable to incorporate in their specifications any part of these requirements, are at liberty to do so; in which case, they should locate the outlets accordingly on the plans accompanying their specifications.

General

The following requirements are the *minimum* that will provide adequate wiring capacity for lighting installations with reasonably small voltage drop. These specifications apply only to installations utilizing 115-volt or 115 to 230-volt distribution and not to wiring for the supply of energy to power equipment, other than that which might be served through the lighting feeders and panel boards.

Since the following requirements are *minimum*, it is recommended that serious consideration be given to the desirability of increasing and elaborating the installation in proportion to the design, scale and appointments of the building.

Classification of Structures—

All buildings used for manufacturing, repairing and handling of materials, including factories, mills, workrooms, repair shops, lofts, inclosed piers and docks, garages, warehouses, etc., shall be considered as industrial structures and shall be eligible for certification under these specifications.

Requirements for All Industrial Structures

All industrial structures shall be wired to provide wattages as set forth in the following table:

Use of space	Watts per sq.ft.	Floor area per lighting circuit sq.ft.	Floor area per convenience outlet circuit
Passage, stairways, storage, etc.	1	1,000	
Rough work, handling of materials, etc.	2	500	See paragraph on convenience outlets
Medium work, offices, etc.	3	333	
Fine bench and machine work, drafting, etc.	5	200	
Extra fine bench and machine work, special operations, etc, and where obstructions are present*		Special design	

* Three watts per sq.ft. shall be provided for general lighting, in addition to which, provision shall be made for supplementary localized lighting to meet the particular needs as dictated by the conditions appertaining to the particular job involved.

Watts Per Square Foot for General Lighting—

All spaces designed for use as passageways, stairways, storage areas, etc., shall be wired to provide a minimum of one watt per square foot.

All spaces where material will be handled or rough work performed shall be wired to provide a minimum of two watts per square foot.

All spaces designed for use as offices, or where medium work will be performed, shall be wired to provide a minimum of three watts per square foot.

All spaces in which drafting, fine bench and machine work, etc., will be performed shall be wired to provide a minimum of five watts per square foot.

All spaces in which extra fine bench and machine work or special operations will be performed, or where there are obstructions which interfere with the correct distribution of the general lighting, shall be wired to provide a minimum of three watts per square foot for general lighting, in addition to which provision shall be made for supplementary

[1] For the convenience of contractors and architects, those fundamental requirements which they may wish to include in their specifications are italicized.

localized lighting to meet the particular needs as dictated by the conditions appertaining to the particular job involved.

Maximum Area to Be Lighted From One Outlet—

No one outlet shall illuminate an area greater than 225 sq.ft. of floor space, except where ceilings are 20 ft. or more in height and where columns or girders would make it desirable or advisable, in which case a bay may be wired with but one outlet, provided that no one side of the bay shall be longer than 25 ft., and that the precision and location of work do not demand closer spacings.

Spacing of Outlets for General Lighting—

No two adjacent ceiling outlets shall be spaced farther apart than the distance from the ceiling to the floor, or the ceiling height in the clear, and outlets shall be arranged so that each will illuminate, as nearly as possible, a square area; except in hallways and corridors, where outlets may be installed up to, but not to exceed, 20 ft. apart. *Spacing between outside outlets and wall shall be approximately one-half regular spacing between units,* except where work benches, desks, etc., are against the wall, in which case, this spacing shall not be more than 3½ ft. Where ceilings are high and the regular spacing of units is great, supplementary lighting for benches should be used as required.

Branch Circuits—

All branch circuits will be considered as carrying a minimum of 1,000 watts on each two-wire circuit or on each side of any three-wire circuit. Circuits 50 ft. or less in length shall be run with wire no smaller than No. 12. For runs over 50 ft., from the panelboard to the first outlet, no wire smaller than No. 10 shall be used for that portion of the circuit and no smaller than No. 12 between outlets.

Runs exceeding 100 ft. from the panelboard to the first outlets shall be avoided wherever practicable by relocation or addition of panelboards. Where such runs cannot be avoided, the initial load on any circuit shall not exceed 600 watts, except in the case of a single lamp of greater wattage, when No. 8 wire shall be used.

Where it is necessary or desirable to install circuits exceeding 1,000 watts in capacity, the circuit wire shall be of such size that the voltage drop on the circuit shall not exceed 2 per cent, with the circuit fully loaded.

Panelboards—

Panelboards shall in all cases contain a minimum of one spare circuit position for each five circuits or fraction thereof in service.

Convenience Outlets—

There shall be not less than eight convenience outlets on any two-wire branch circuit or on each side of any three-wire branch circuit. No convenience outlets shall be connected to lighting circuits.

There shall be at least one convenience outlet in each 1,200 sq.ft. of manufacturing space and one in each 2,400 sq.ft. of storage space, except where small portable tools will probably be used, in which case areas to each outlet shall not exceed 600 sq.ft. There shall be one outlet in each 400 sq.ft. of office space.

No wire smaller than No. 12 shall be used for convenience outlet circuits. Runs exceeding 100 ft. from the panelboard to the first outlet shall be avoided wherever practicable by relocation or addition of panelboards. Where such runs are unavoidable, no wire smaller than No. 10 shall be used to the first outlet and no smaller than No. 12 between outlets; except where devices rated at 500 to 1,650 watts input are likely to be connected, when No. 10 and No. 8 wire shall be used instead of No. 12 and No. 10 respectively.

Service and Feeders—

In computing service and feeder sizes, all circuits, including spares on the panelboards which they feed, shall be considered fully loaded (1,000 watts as a minimum on each two-wire circuit or on each side of any three-wire circuit). They shall be of such a size that the voltage drop shall not exceed 2 per cent from the service entrance to any panelboard at full load. If the initial load, or the load likely to be added, is greater than 1,000 watts per circuit, the size of service and feeders shall be increased proportionately.

Conduits and ducts for inclosing service and feeders shall be of sufficient size to permit replacing the original service and feeders with wires 50 per cent greater in capacity.

*Street and Highway Lighting**

The major activity of the street and highway lighting committee this year has been the preparation of a report containing traffic statistics of interest to Californians and also a plan of highway lighting which it hopes to see put into effect over a trial area.

THE street and highway lighting committee reports that during the year it has developed a very comprehensive highway lighting plan which gives consideration to traffic statistics of interest to Californians, and to the mileage of the several classes of highways within the state. The amount and distribution of money collected from the several sources and the expenditures from the construction and maintenance of highways is reviewed. The economic loss due to poor visibility at night is detailed and summarized.

In the report there is listed the important advantages of highway lighting and a statement of the annual cost per mile to maintain and operate such lighting. The cost to operate and maintain highway lighting is also compared with the cost to construct and maintain highways. The committee has suggested the trial installation of a 50-mile length of good highway lighting, all to be suitably located with respect to accidents and travel conditions, and it has listed a considerable number of service clubs and civic bodies which should be advised as to the propriety and economy of installing highway lighting.

A plan and a detailed estimate of the cost of introducing such a plan concludes the report.

For the past year or more it has been a very real hardship for cities to collect taxes to pay the annual cost of street lighting. For this reason, the public utilities of the state have not aggressively pushed the sale of additional street lighting. It is gratifying to note that not more than one or two cities have requested any elimination of existing street lighting in order to divert public funds to other causes.

* Report of the street and highway lighting committee, lighting bureau, Commercial Section. W. P. Bear, chairman. C. M. Bliven, C. E. Hewes, C. E. Johnson, K. M. Koch, E. P. Markee, F. B. Nightingale, George Riley, F. J. Wellhouse.

*Home Lighting**

In deciding upon the work for this year, the home lighting committee felt that the work of last year's committee along the lines of advertising, publicity and display, consumer education and employee education, should be continued. The committee also felt that the member companies of the association were not sufficiently informed as to the exact conditions prevailing in California homes in regard to the number and wattage of sockets in use. A survey of the home lighting field was there-

* Report of home lighting committee, lighting bureau, Commercial Section. R. A. Buckby, chairman. W. E. Carlson, D. F. Collier, L. S. Lothridge, Ann Pennington, C. F. Wolf.

fore contemplated. The objectives for the year covered the following topics:

1. *Survey of home lighting field*
2. *Central station employee education*
3. *Advertising publicity and display*
4. *Consumer education.*

THE committee decided to use the following methods to attain its objectives for the year:

1. Questionnaire.
2. Central station home lighting courses.
3. Submission of suggested ideas.
4. Chapter for P.C.E.B. booklet and suggested use by home economic demonstrators of visual education.

In an effort to determine the existing conditions in California homes, a questionnaire was prepared and sent out to member companies of the association with the suggestion that they circulate a questionnaire of this nature among their own employees to give them at least a start in determining the actual conditions. The questionnaire follows:

HOME LIGHTING QUESTIONNAIRE

PACIFIC COAST ELECTRICAL ASSN. HOME LIGHTING COMMITTEE

The home lighting committee of the P.C.E.A. appreciates your help in determining the existing home lighting conditions by answering the following questions. This is not to sell you anything—merely an index of how California homes are utilizing lighting services. Do Not Sign Your Name. We request your answers and thank you for your cooperation.

1. What types of lighting fixtures do you use? How many of each type have you? What is the total number of sockets in each type? The total wattage of each type? Are the lamps shaded or not?

ROOM	TYPE UNITS	NUMBER UNITS	SOCKETS		SHADED	
			Total Number	Total Watts	Yes	No
Living	Portable Wall Ceiling	— — —	— — —	— — —	— — —	— — —
Dining	Portable Wall Ceiling	— — —	— — —	— — —	— — —	— — —
Kitchen	Ceiling Wall	— —	— —	— —	— —	— —
Breakfast	Ceiling Wall	— —	— —	— —	— —	— —
Bedroom	Portable Wall Ceiling	— — —	— — —	— — —	— — —	— — —
Bedroom	Portable Wall Ceiling	— — —	— — —	— — —	— — —	— — —
Bathroom	Ceiling Wall	— —	— —	— —	— —	— —

2. Do you own or rent your home?

Check one: Own..... Rent.....

3. If you rent, do you rent furnished or unfurnished?

Check one: Furnished..... Unfurnished.....

4. Do you consider the illumination satisfactory?

Check one: Yes..... No.....

5. Would you improve the lighting if it incurred only a small expense?

Check one: Yes..... No.....

Central station home lighting courses, as prepared by mazda lamp manufacturers, are considered the best means of educating central station employees in this subject. It is felt that employees must be well acquainted with their subject before they are in a position to sell more and better home lighting to their consumers. Such a course has been used by several of the power companies this year.

There are many sources of information on the subjects of advertising, publicity and display. The advertising and display managers of member companies have been furnished with suggested newspaper ads and store and window displays.

RESULTS

The committee has circulated some 150 to 200 questionnaires among wholesale distributor organizations and has supplied each power company in the state with samples of the suggested questionnaire. Up to the present time, 176 answers have been received. The committee felt that the kitchen item was perhaps the figure of greatest interest. These 176 returns indicate an average of 73 watts per kitchen. While we realize that with such a small number of replies, answers could not be taken as representing exact existing conditions, this figure at least gives some idea that the homes in California are not using suggested wattages in their kitchen and that as a result, the consumers are suffering from a lack of illumination. It is recommended that the home lighting committee of next year further this work and continue to tabulate the results of the various company questionnaires if and when they are distributed.

As part of the committee's work in connection with employee education, 155 employees have finished a home-lighting course and diplomas have been issued by the lamp manufacturer, signifying their completion of this series of lessons. The committee most heartily recommends this type of education and suggests that these classes be continued throughout the coming year.

Figures on cooperation with the various advertising and display departments of the power companies are not complete. Demonstrations have been made throughout the year. One company, at least, has taken the advertisements suggested by the committee, as the main idea of its lighting schedule, which calls for 66 newspapers, with 11 advertisements in each throughout the year.

A chapter was prepared for the Pacific Coast Electrical Bureau booklet, which is given as an appendix to this report.

RECOMMENDATIONS

In view of the fact that preliminary results indicate an average wattage of 73 watts per kitchen, a continuation of advertising is recommended. There is also a new kitchen lighting unit on the market designed to hold a 150-watt lamp only and the committee suggests the use of this unit or a similar one to the member companies, for offer to their consumers. The addition of this unit to the kitchens on their lines would undoubtedly result in increased lighting satisfaction for their consumers and a desirable revenue for the power companies themselves.

In connection with employee education, we recommend the continuation of courses similar to those carried on this year, especially for all employees who contact the public. There is also a great opportunity to extend this work to other employees. We feel sure that any effort put behind this educational work will more than repay itself.

The continued use of all forms of displays and advertising is recommended to tie in with the educational committee's work, such as has been carried on by Clark Baker during the past season.

Last year's report recommended furthering the sale of the 200-watt and 300-watt indirect portable lamps. From such information as we are able to gather, the sale of this item has increased remarkably. We do not hesitate to recommend more effort behind this line.

In conclusion, and summoning up the points outlined above, we believe that home lighting is perhaps the most impor-

tant form of lighting in the present-day markets and that the continued use of merchandising fundamentals, such as window displays, store displays, "ask 'em to buy" newspaper ads and word of mouth and education are the prime factors in ultimately satisfying every electrical consumer.

Appendix—Chapter on Home Lighting For P.G.E.B. Booklet

ANY complete discussion of home lighting would have to take into account the personal tastes of the reader with regard to design, architecture, and decoration. That is almost an impossibility——and as a result this chapter on home lighting will eliminate personal tastes, and deal with the fundamentals of good modern home lighting equipment, with suggestions for use, according to location and activity in the home.

First Requisite is Wiring

Before any suggestion may be made, we must assume that the home has adequate wiring—wiring of the sort that allows one to obtain light wherever and whenever needed. This does not mean extravagant wiring, but rather the provision to place lamps where one wants them. Relatively few additional outlets over the usual number provided will add greatly to convenient and adequate wiring. This subject is discussed further in detail in another chapter of this book, but we must bear in mind—*adequate wiring is the prerequisite to good lighting.*

General Considerations

The actual problem of lighting homes may be considered to be divided into two sections: 1. Utilitarian, 2. Decorative. We naturally need light for reading, cooking, sewing, and for other household activities, and our personal desire for beauty and decoration demands additional light sources. In some fixture designs, both elements must be considered. In a combination-purpose fixture of this nature, illumination qualities and other features should receive consideration in proportion to the total in the following percentages:

	Per Cent
1. Illumination qualities	50
2. Construction and finish	20
3. Appearance	30
Total consideration	100

Other important general rules are:

1. Have every lamp shaded.
2. Have enough fixtures to provide for all areas.
3. Have lamps of sufficient size in each fixture to provide satisfactory light.
4. Have fixtures harmonize with architecture, furniture and decoration.

In view of these simple rules, let us look at the home, room by room. But first these room-by-room considerations, whether utilitarian or decorative, or a combination of both, must be viewed with the idea that the following suggestions may be applied equally to relighting older homes with antiquated equipment, as well as in the design of new dwellings.

Home Lighting Suggestions

As stated above, home lighting should be personalized to agree with the individual requirements, so the following suggestions must necessarily be fundamental and applied to these individual requirements.

The Porch—

Your home is first revealed by the porch. Good lighting will emphasize details and insure that steps will be clearly seen. A single unit (40 to 60-watt) over the door or on the ceiling may prove satisfactory, but one unit (40 to 60-watt) on each side of the doorway is preferable. Copper units will not mar the building with rust streaks.

An illuminated house number is a convenience that should be incorporated. This feature may be a part of the lighting units themselves or a separate illuminated number may be used, using a 5 or 10-watt lamp. Some manfacturers have a combination house number and doorbell unit, operating from a doorbell transformer and using a lamp similar to those in radio sets.

Another feature of the porch is to add one or two convenience outlets, in order to make available decorative lighting such as Christmas trees, lantern, and other decorations used on various occasions.

Halls—

For every hall a ceiling fixture of at least 60 watts capacity should be provided. This of course should be increased for large areas. This unit should be shaded to prevent glare from the lamp bulb, and should direct the light downward, but with sufficient light on the ceiling to brighten it materially.

Living-Room—

Living-room activities vary so widely for various occasions and occupations that the lighting must be very flexible. Surely one doesn't want the same light in use when enjoying restful occupations as when a large joyous company is entertained.

The first principle in a living-room is to provide for a ceiling fixture. No home is complete without one. This fixture should be properly shaded, should provide adequate light on the ceiling itself to eliminate sharp contrast, and should provide for a minimum of 200 watts (five 40-watt, four 60-watt, are examples). This unit, of course, is not necessary all the time. When enjoying the company of intimate friends and not engaged in bridge or the like, low levels of illumination are quite satisfactory and can be obtained from shaded wall brackets and portable lamps.

It may be well to state here that shades should not be closed at the top. Open shades permit the light to relieve contrast by lighting side walls and ceiling. This produces more eye comfort than sharp contrasts afford. For rooms with low ceilings, eight or nine feet in height, the mass of the unit should be close to the ceiling. This minimizes the apparent size and adds to the expanse of the room, in addition to preventing the unit being in the field of observation.

For portable lamps, 60-watt lamps should be used in each socket. Wall brackets require from 25 to 60 watts each, depending on the number of globes per unit. The average is 60 watts per unit, and they should be mounted 72 in. above the floor. Decorative ornaments use 5 to 25 watts each.

Dining-Room—

Shower and candle-type fixtures are satisfactory for the dining-room, but the usual tendency is to mount them too high. All lamps must be shaded and for these types, 36 in. above the table is the practical maximum mounting height. These shower and candle-type units should be supplied with five 40-watt lamps, or the equivalent, in the event the number of sockets is greater or less.

Dome-type units are also well adapted, providing they are mounted low enough to prevent the lamp being visible, and high enough to permit vision across the table. The correct distance from table top to the bottom of the dome is generally 24 in. This type of unit should be supplied with a 100 or 150-watt lamp.

Wall brackets are not generally satisfactory for dining-room use except for decoration and to relieve contrasts. These brackets should have 40 to 60 watts in each socket.

Breakfast-Room—

Cheerful light, especially on dark mornings, is an asset to any home. A single ceiling suspended unit with a decorated inclosing shade, and having a 60-watt lamp, provides cheerful light for the average breakfast nook. Larger breakfast-rooms require the use of 100 to 150-watt lamps in similar units.

Kitchen—

The workshop of the home needs plenty of well-diffused illumination. One totally inclosed glass unit at the center of the ceiling with a 100 or 150-watt lamp will furnish good general illumination. This should be supplemented with a wall unit over the sink. This eliminates the worker's objectionable shadow. This unit should be mounted 66 in. above the floor and be supplied with a 60-watt lamp. A similar unit near the stove also aids in making the kitchen more cheerful and workable.

Bedroom—

The most desirable type of ceiling unit for the bedrooms is one which has low brightness and is therefore comfortable to the eyes of one lying in bed. A unit with two or three 40 to 60-watt lamps, or equivalent, totally inclosed by a plain or decorative shade, is satisfactory. This should be supplemented by a bed lamp and brackets or table lamps at the dressing table. The bed lamp should be well shaded and have the equivalent of 75 watts. In the case of twin beds, a portable lamp, where the lamp bulbs are 40 to 50 in. above the floor (depending on bed height), and using the equivalent of two 60-watt lamps, is recommended. The dressing table should be lighted from each side, either by wall brackets or table lamps. The light bulb itself should be located so that it is 6 in. higher than eye level, that is, 66 in. when standing and correspondingly lower when sitting down.

Bathroom—

In most bathrooms, a wall bracket on each side of the mirror will provide adequate light for shaving, and serve for the entire room, although a ceiling unit similar to the kitchen unit adds further flexibility and lighting comfort. The wall brackets should have the lamp bulbs shaded and mounted 66 in. above the floor. Sixty-watt lamps for each is the proper size.

There are, depending upon family income and location, more or less rooms than those herein outlined, but from these general principles, the reader may easily see the fundamentals and can apply the conditions shown to any other location he desires to illuminate.

In conclusion, emphasis should be applied to the general fundamentals:

1. Have every lamp shaded.
2. Provide plenty of outlets.
3. Use lamps of adequate wattage.

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*Sign and Outdoor Lighting**

The sign and outdoor lighting committee planned the carrying out of two objectives, first the organization of floodlighting and sign-lighting manufacturers in a group, so that a thorough discussion could be held with the individuals of each group, and as a result, one or more constructive suggestions obtained. Second, the planning of a united educational campaign to be carried on with the consumer for the purpose of cutting down the sales resistance, so as to create a more favorable desire in the mind of the consumer for outdoor advertising.

MANY plans of cooperation with sign manufacturers and floodlighting manufacturers were considered by the committee, of which two offer possibilities of being worked out into a most satisfactory cooperative campaign, providing the necessary support of manufacturers can be obtained. A continuance of this endeavor is recommended to the succeeding committee.

The floodlighting plan is that which is being carried out by the General Electric Co., combined with the demonstration trucks, sketches and costs, which have been adopted as prepared by William Bear and his committee, in their recommendations to the Pacific Coast Electrical Bureau. A sign manufacturer's plan is that which is being carried out at the present time by the Electric Products Co. and the Pacific Gas and Electric Co. Both of these plans call for a selected prospect list obtained by men in the field. These prospect lists could be turned over to the Pacific Coast Electrical Bureau, and a series of high-class circulars mailed to them. Such circulars should carry a return postcard and there should not be less than three or four mailings. These should then be followed up by floodlighting tests, photographs and sketches, showing prospects how their building will look when a completed job.

All tests and demonstrations should be carried on under first class salesmen, with the ability to close jobs. The method of distributing returns from prospects must be worked out by a committee selected by the sign or floodlighting manufacturers, the Pacific Coast Electrical Bureau and the utility interested.

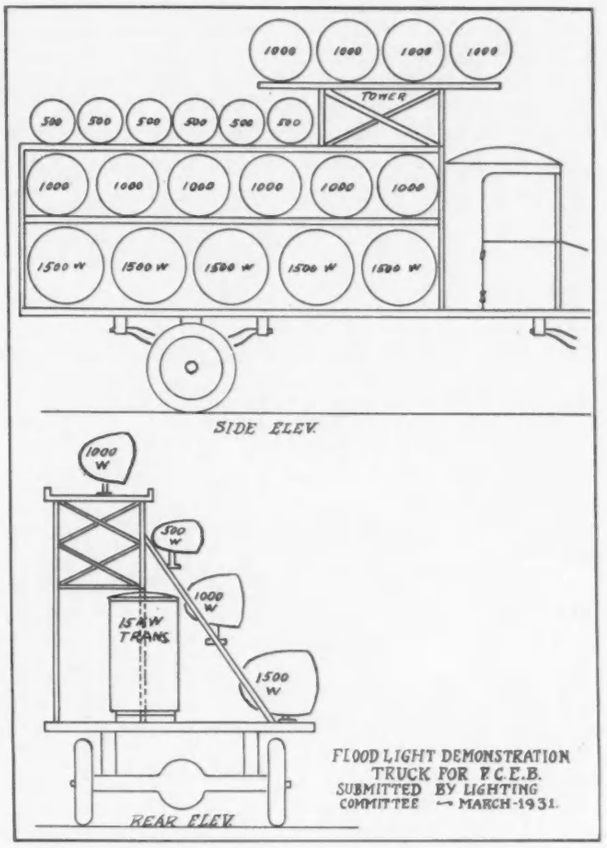

Fig 1—Floodlight demonstration truck planned for the Pacific Coast Electrical Bureau

* Report of sign and outdoor lighting committee, lighting bureau, Commercial Section. W. S. Hanbridge, chairman. Walter Carlson, F. B. Nightingale, vice-chairmen. Frank Bevan, R. C. Dalton, Frank Hansen, J. E. Hammond, N. Hearne, Jr., W. J. Moreland, Roy Myers, D. J. Prudhomme, S. Russell, R. B. Smith, L. M. Watson, H. B. Wells.

Conclusion

The committee will continue the work of getting together those interested, so that it will be able to turn this matter over to the incoming committee, in as complete a form as possible. Your committee also recommends that the Pacific Coast Electrical Bureau appoint a committee in the northern part of California and one in southern California, to hold an electrical advertising show in Los Angeles and in San Francisco, and if practicable, in some of the other large cities of the state, such as Sacramento, Stockton, Fresno, Santa Barbara and San Diego.

*Floodlighting**

The objective of this committee of the P.C.E.B. was to further outdoor and floodlighting by the use of practical demonstration equipment and to carry out actual examples of outdoor and floodlighting.

FLOODLIGHTING and outdoor lighting serves many purposes. It is a powerful advertising medium to attract attention to office buildings, industrial plants, service stations, stores, banks and theaters; it affords a means of producing artistic and aesthetic effects on fountains, churches, arches and structures of unusual design; it stimulates civic pride by giving prominence to public buildings, monuments and statues; it increases the hours of recreation at play grounds, beaches and stadiums; it serves utilitarian and protective purposes in railroad yards, docks, industrial plants and construction work.

* Report of P.C.E.B. committee on floodlighting included as part of report of sign and outdoor lighting committee, lighting bureau, Commercial Section.

Recommendation

Your committee recommends that the Pacific Coast Electric Bureau furnish, equip and operate a demonstration truck to be rented to member companies for their use.

Summary of Estimated Cost

Truck ready to run	$1,400
Monthly cost of operation	400
Revenue from truck rental	400

On the above basis, the only cost to the Bureau of this equipment will be the first cost of the truck.

Your committee is willing to design the truck, superintend its construction and assist in its operation.

MERCHANDISING BUREAU REPORTS[2]

*Small Appliances**

A variety of causes have resulted in a marked reduction in the sale of small appliances. The committee makes recommendations for meeting this situation.

[2] Pierre Vinet, Coast Counties Gas & Electric Company, chairman.
American Bakery Equipment Company: H. L. Kean.
Geo. Belsey Company: Gaybert Little.
Central Arizona Light & Power Company: R. A. Best.
Cline Electric Company: A. V. Cline.
Coast Counties Gas & Electric Company: R. C. Dalton.
H. R. Curtis Company: Arthur Rector.
Dohrmann Hotel Supply Company: W. D. Selleck.
Edison General Electric Appliance Company: C. F. Allen, J. P. Bowden, R. J. Cordiner, L. A. Francis, L. H. Robinson.
Electrical West: Wm. A. Cyr.
Everhot Electric & Manufacturing Company: H. Fogwell.
Frigidaire Sales Corporation: G. W. Shane.
General Electric Company: E. J. Cipperly, J. O. Dillingham, L. D. Fowler, H. Gerster, M. J. Murphy, G. J. Ruck, G. S. West.
General Electric Supply Corporation: A. W. Krueger, C. H. Thrane.
Graybar Company: H. C. Goldrick, R. W. Kimberlin, A. H. Nicoll.
Hoffman Specialty Company: H. H. Daley.
Los Angeles Gas and Electric Corporation: F. L. Moon, Miss J. B. Taylor.
A. J. Lindemann & Hoverson Company: H. W. Lippert.
Midland Counties Public Service Corporation: G. V. Footman.
Pacific Coast Electrical Bureau: F. J. Kiefer, R. M. Maxwell, H. W. Stitt.
Pacific Gas and Electric Company: O. R. Doerr, E. W. Florence, E. F. Perkins, D. C. Ray, A. A. White.
Premier Vacuum Cleaner Company: C. J. Jones.
Carl I. Rohr Electric Company: Carl Rohr.
San Diego Consolidated Gas & Electric Company: A. I. Benedict, W. J. Gilmour, Alfred May.
San Joaquin Light & Power Corporation: J. E. Hammond, P. B. Wilson.
Sierra Pacific Power Company: O. S. Clifford.
Southern California Edison Company Ltd.: A. W. Althouse, R. E. Bacon, L. A. Bartlett, H. V. Busby, C. M. Campbell, H. H. Douglas, H. J. Drexel, C. H. Hess, J. H. Mead, J. D. Mercer, P. V. Moffat, H. J. Moulton, P. H. Needham, A. L. Pryor, H. C. Rice, R. M. Taylor, L. S. Tudor, R. R. Walbridge, H. E. Welsh, Ray Whitson.
The Southern Sierras Power Company: G. T. Bigelow, S. A. Cundiff, W. S. Fleming, J. G. Nusbaum.
Southern Wesix Heater Company: L. A. Krieg.
Thor Pacific Company: L. R. Swenson.
Tucson Gas Electric Light & Power Company: A. E. Morrison.
Vallejo Electric Light & Power Company: E. B. Pierce.
Valley Electric Supply Company: R. W. Downing.
Wesix Inc.: C. A. Russell, A. Strauch.
Westinghouse Electric & Manufacturing Company: J. A. Clark, L. F. Church, Ivan de Jongh, H. L. Garbutt, M. S. Henoch, R. E. Larsen, C. H. Paulin, T. A. Reid.
Westinghouse Supply Company: R. F. McDonald, D. C. Pence, S. A. Searle.

* Report of appliance committee, merchandising bureau, Commercial Section. A. W. Krueger, chairman. A. W. Althouse, R. A. Best, J. P. Bowden, C. M. Campbell, R. W. Downing, C. J. James, R. W. Kimberlin, R. E. Larsen, M. J. Murphy, D. C. Pence, Miss J. B. Taylor, G. L. West.

THE exception decrease in small appilance business has created a merchandising problem upon which the attention of the committee was concentrated to determine the basic causes and suggest remedies.

It is the opinion of this committee that the following factors have been mainly responsible for the unusual decline of small appliance business, particularly heating devices:

1. Liquidation of manufacturers' discontinued numbers at prices which stagnated movement of current merchandise.
2. Marked increase in sale of substandard appliances at low prices.
3. Concentration of merchandising attention on large appliances.

Liquidation in the main has about run its course. This committee recommends, however, that manufacturers coordinate the sale and distribution of discontinued merchandise through wholesalers and dealers on a plan that will assure participation on an equal basis by all retail agencies.

Many retail outlets have entirely overlooked the basic advantages of quality, service, consumer confidence and stability of investment that are inherently a part of standard lines. Price has been the dominating consideration. This committee recommends that all retail appliance selling agencies again give consideration to these fundamentals for increasing their appliance business. Standard lines are in step with existing market conditions but have not sacrificed quality or service.

Unquestionably the promotion of small appliances has suffered to an undue degree because of sales concentration on major devices. Certainly present day small appliances merit special sales activity. A tremendous market exists for automatic appliances of all kinds to replace the older types requiring manual control—flatirons and waffle irons, in particular. Coffee-making machines properly presented will attract many buyers. Small mixers and juice extractors are marvelous labor savers and will more than justify a specialized selling effort.

Health Appliances

This committee recommends that all retail selling agencies make a special study of the tremendous potential market for ultra-violet radiation treatment with sunlamps. No market offers greater possibilities than the maintenance and normalizing of human health. Intelligent application and use of

modern sunlamps or ultra-violet radiation treatment is so desirable that no home would be without one, once the true value of this appliance were fully realized. Our job obviously is to see that every retail selling agency has a thorough understanding of what ultra-violet radiation is and what it will do. This information can be simply transmitted and readily understood. It is not hard to understand. Manufacturers and wholesalers will be glad to cooperate in this work.

This committee feels that so important is the market for ultra-violet radiation that immediate steps should be taken by all retail appliance selling agencies to make plans to merchandise this valuable appliance and stir to activity the exceptional market that is waiting.

*Motor Driven Appliances**

It is urged that special attention be given the ironing machine, which, it is felt, now offers a large potential market.

THE committee has nothing new or novel to offer for increased exploitation of washing machines and vacuum cleaners. It is recommended that principles which have been so successful for the past few years be continued. It is suggested that home demonstration, particularly on washers, be encouraged as much as possible. Vacuum cleaners are rapidly getting into the category of counter devices, but intelligent coordination of personal contact, plus store selling, is essential.

The broadest potential market unquestionably is that for ironing machines, which is nationally saturated to approximately 3 per cent. The electric ironing machine offers an exceptionally fertile field for creative selling. It has all the natural advantages to attract purchasers. Simplicity of operation and moderete prices are now available.

This committee recommends that a great deal more effort be directed to the ironing machine by retail selling agencies, using a demonstrator to visualize the desirability of this product, and adopting aggressive newspaper and direct-by-mail campaigns to crystallize public realization of the value of this appliance.

In conclusion the members of this committee feel that proper organization and presentation in the appliance field will produce greater volume in all lines than has ever been enjoyed in the past.

* Report of motor-driven appliance committee, A. W. Krueger, chairman. J. A. Clark, L. D. Fowler, C. H. Hess, J. H. Mead.

*Domestic Electric Ranges**

In addition to the following record of accomplishments for the year, the electric range committee has completed a chapter on the domestic electric range for the appliance merchandising handbook.

SUBJECTS and objectives discussed by the committee are as follows:

1. National range sales campaign.
2. Promotion of employee range sales through P.C.E.B.
3. Promotion of slogan.
4. Free range wiring.
5. Portable range wiring.
6. What the range load is worth to the utility.
7. Cooperation between the utility and the dealer.
8. Cooking schools.
9. Methods of selling.

* Report of the electric range committee, merchandising bureau, Commercial Section. P. B. Wilson, chairman. H. V. Busby, R. J. Cordiner, R. W. Downing, W. S. Fleming, G. V. Footman, H. L. Garbutt, M. S. Henoch, R. W. Kimberlin, A. W. Krueger, H. W. Lippert, R. F. McDonald, J. D. Mercer, P. V. Moffat, C. H. Paulin, E. B. Pierce, L. R. Swenson.

National Range Sales Campaign

There is little that can be done in connection with the national campaign until the program has been outlined and made ready to put into effect. A letter has been received from J. W. Busch, chairman of the national domestic range committee, saying that this plan would be submitted at the Nationel Electric Light Assn. meeting in Chicago on March 23.

Promotion of Employee Range Sales Through P.C.E.B.

The committee felt that this work should be followed up very carefully to promote the "use it yourself" idea among all utility company employees, in fact, among all of the employees of the industry. Both selling organizations and non-selling organizations cannot hope to do a good selling job unless they use an electric range themselves.

Promotion of Slogan

The slogan adopted by the committee is as follows:

Electricity is your best servant. Adequate wiring is necessary. Consult your dealer or us.

This slogan can be used in a number of different ways, and, as was suggested at the Bureau, the idea can be followed up.

Free Range Wiring

There have been many discussions on the subject of free range wiring and there is, of course, a wide difference of opinion as to whether or not the utility should capitalize the wiring cost or include it in sales expense. It is hoped that some information on this subject will be available from the national range committee.

Portable Range Wiring

Definite methods of portable range wiring were discussed. The method used by the California Oregon Power Co. was considered to be very good. This company has, however, later adopted the free-wiring idea.

What the Range Load Is Worth to the Utility

This ties in with the free range wiring idea, and again there is a wide difference of opinion as to the value of the range load to the utility.

Cooperation Between the Utility and the Dealer

This, of course, is being followed up and is a very definite work of the Bureau. There are definite methods of cooperation in use in different parts of the state. The national range program will undoubtedly cover this subject very thoroughly.

Cooking Schools

The committee felt that cooking schools or cooking parties are very important in promoting the sale of electric ranges. Entertainment, prizes and refreshments are attractions that can be used to interest the housewife. The home economics department, which is considered a very important part of any sales organization, is promoting the sale of electric ranges.

Methods of Selling

A great many ideas were brought forth in this connection. The use of the brooder was suggested as a very valuable part of the salesmen's work. It is considered a good "door opener."

Every salesman should know how to use and how to cook on the electric range. Territory should be very carefully analyzed and the saturation should be carefully determined. Adequate manpower and advertising must be provided.

The national range sales program should and will, without a doubt, cover this subject thoroughly.

*Electric Air Heating**

The air heating committee for 1932 found its principal activities in the preparation of a chapter covering the subject of air heating for inclusion in the Pacific Coast Electrical Bureau booklet on home electrification, and the compiling of data concerning insulation as applied to various classes of construction.

The objectives of the committee for 1932 were as follows:

1. *Cooperate with the air conditioning committee, as required by that committee.*
2. *Prepare a chapter on air heating for the P.C.E.B. home electrification booklet.*
3. *Endeavor to outline a sales policy to put over better the idea of electric space heating by:*
   - *(a) Requesting that the Bureau advertising committee give more consideration to the advertising of space heating in its 1932 program.*
   - *(b) Cooperation with the P.C.E.B. air heating committee for the purpose of endeavoring to outline a sales and advertising policy.*
   - *(c) Endeavoring to stimulate a greater interest in the sale of heaters and equipment in the ranks of contractors and jobber salesmen.*
4. *Make a study of types and values of insulation for the purpose of determining actual rather than theoretical savings. Determine cost per kw. connected per year for various sized residence installations. Subcommittee: H. H. Douglas, M. L. Hooper, L. A. Bartlett.*
5. *Investigate the safety requirements of 440-volt air heating equipment. Subcommittee: R. H. Robinson, H. H. Douglas, H. H. Daley, L. A. Bartlett.*

Cooperation With Air Conditioning Committee

THIS year's air conditioning committee, having decided to publish a manual for power company salesmen which would outline the advantages and sales arguments of air conditioning, found it unnecessary to call upon the air heating committee for cooperative assistance.

Air Heating Chapter for Home Electrification Booklet

This work is completed and in the hands of the bureau chairman. It is the opinion of this committee that the script as prepared by C. A. Russell, which has been approved by the committee, is a most complete resumé of the subject. It is the contention of the committee that the script as approved should be used without excessive condensing or deleting. The story is well told and covers only such sales arguments as are required for publicity purposes.

Outlining a Sales Policy

The committee appreciates the fact that bureau advertising will provide for fourteen insertions in various publications of advertising relating exclusively to air heating. This will appreciably assist in putting over the story to the potential user of the equipment.

Inasmuch as the personnel of the bureau's air heating committee is substantially the same as that of the association, no joint meetings were held.

The formation of a new activity for the purpose of more fully cooperating with contractors and jobber salesmen was thought unadvisable for this year; the suggestion being made that the idea be passed on to next year's air heating committee.

Safety Requirements of 440-Volt Heaters

The subcommittee covering this subject conferred with Frank Short of the California State Safety Commission and was informed of the commission's requirements covering the installation of the equipment. Mr. Short expressed his, and the commission's willingness to assist manufacturers, jobbers, contractors, and utilities in the installing of present equipment until such a time as state specifications of manufacture and installation had been adopted which might prove mutually satisfactory. Further investigation as to requirements has been passed on to manufacturers, with a request that they continue this subject with the California State Safety Commission.

Report of Subcommittee on Home Insulation

In the successful promotion of the sale of electricity for heating purposes, the matter of house insulation becomes of greater importance than when cheap fuel is used for heating.

It is sometimes difficult to convince the consumer that good construction and insulation is advisable, but if a careful study is made of the better methods of insulation, it is usually possible to show the consumer that the slight additional cost of insulation is fully justified for its other manifest advantages, other than for saving heat losses.

If, however, the consumer is not interested in any other than the economy factor for heating purposes only, he should be convinced of the economy on this basis. Manufacturers claim fuel economy of from 25 per cent to 50 per cent. We give some supporting data on this point here, which show the revenue per kilowatt of connected heat load to be 32 per cent greater in an uninsulated house than in one that is insulated.

We have reliable information that average medium-sized homes can be insulated at an additional cost of from $5 to $30 per room with a probable cost of $25 per room for insulation that will get very effective results under average conditions. This would mean that an eight-room house would cost, under average conditions, $200 more, if effectively insulated to the best advantage.

In Tables I and II information is given on ten insulated homes and ten uninsulated homes. These are all characteristic electrically heated homes, picked at random and distributed all over the Southern California Edison Co. system. They were not selected with any particular reference as to size or condition under which they might have been operated. The selection was made in this way in order to get as true a cross-section picture, as is possible, of the economy gained from insulation. Other reasons than insulation or lack of insulation may have contributed to the economy or to the heavy use, as the case might be, but it was thought that by using this number of each group any great irregularities in either group would be smoothed out by the law of average, producing an average figure which would be fairly characteristic of the probable economy which can be credited to insulation.

It should be understood that all of these consumers are on a combination meter with lighting, heating, cooking and appliance all on one meter. It is therefore difficult to determine exactly the amount of energy used for heating only. The following method has been developed to determine the probable amount chargeable to heating.

It is quite probable that very little, if any, heat is used during the months of May to October, inclusive. It is therefore assumed that energy used during these months is used for purposes exclusive of heating. A figure can be constructed from this average summer use which would be applicable for use exclusive of heating throughout the year. If this amount used for purposes exclusive of heating for a

* Report of air heating committee, merchandising bureau, Commercial Section. F. L. Moon, chairman. H. H. Douglas, vice-chairman. L. A. Bartlett, E. J. Cipperly, W. E. Cranston, Jr., H. H. Daley, W. S. Fleming, H. C. Goldrick, M. L. Hooper, L. A. Krieg, E. F. Perkins, E. B. Pierce, L. H. Robinson, C. A. Russell.

TABLE I—Data on Insulated Homes.

Consumer	Location	Kw. Connected Load: Range	Water Heater	Heat	Total	Annual Use: Kw-hr.	Amount	Annual Cost Exclusive of heat	Balance Chargeable to heat	Cost per Kw. Heat	Type of Insulation
A	Ventura	8.5	5.0	30.0	43.5	9,083	$221.32	$154.20	$67.12	$2.24	Celotex
B	Pomona	9.6	5.0	16.0	30.6	7,467	174.30	156.04	18.26	1.14	Celotex
C	Porterville	7.8	5.0	22.0	34.8	16,129	278.56	158.76	119.80	5.44	Insulex
D	Santa Barbara	8.5	10.0	49.0	67.5	39,810	774.04	508.08	265.96	5.42	Insulex
E	Whittier	8.5	5.0	26.0	39.5	15,835	358.50	302.80	55.70	2.14	Celotex
F	Hollywood	8.5	None	72.0	80.5	13,369	372.27	202.52	169.75	2.36	Celotex
G	San Marino	8.0	10.0	48.0	66.0	8,690	209.80	169.20	40.60	0.85	Insulite
H	Santa Paula	8.0	5.0	29.0	42.0	7,561	191.81	112.36	79.45	2.74	Celotex
I	El Monte	8.0	5.0	26.0	39.0	13,255	289.12	213.32	75.80	2.95	Celotex
J	Hollywood	21.0	7.0	58.4	86.4	46,384	967.68	693.36	274.32	3.59	Celotex
	Totals	96.4	57.0	376.4	529.8	177,583	$3,837.40	$2,670.64	$1,166.76	....	
	Average	9.64	5.7	37.64	52.98	17,758	383.74	267.06	116.68	$3.10	

TABLE II—DATA ON UNINSULATED HOMES

Consumer	Location	Kw. Connected Load: Range	Water Heater	Heat	Total	Annual Use: Kw-hr.	Amount	Annual Cost exclusive of heat	Balance Chargeable to heat	Cost per Kw. Heat
L	Beverly Hills	9.0	5.0	24.0	38.0	18,139	$387.99	$256.54	$131.45	$5.48
M	Redlands	7.9	5.0	19.0	31.9	13,318	303.23	222.02	81.23	4.28
N	Simi	7.8	8.0	31.6	47.4	18,930	414.60	266.00	148.60	4.70
O	Whittier	13.2	8.0	30.0	51.2	19,063	421.37	280.35	141.02	4.70
P	Puente	13.8	10.0	37.8	61.6	24,635	532.80	432.54	100.26	2.66
Q	Beverly Hills	None	None	31.0	31.0	9,946	238.18	122.58	115.60	3.73
R	Puente	7.0	7.0	12.0	26.0	18,563	410.90	342.44	68.46	5.20
S	Whittier	13.6	11.0	79.0	103.6	44,190	924.91	791.40	133.51	1.69
T	Lancaster	7.5	3.5	16.0	27.0	29,233	527.08	294.40	232.68	14.55
U	Santa Ana	7.8	5.0	22.6	35.4	11,944	279.24	186.46	92.78	4.10
	Totals	87.6	62.5	303.0	453.1	207,961	$4,440.30	$3,194.67	$1,245.59	....
	Average	8.76	6.25	30.3	45.31	20,796	444.03	319.47	124.56	$4.11

year is deducted from annual use, it is reasonable to believe that the remainder would be characteristic of what may be reasonably chargeable to heating.

In order to emphasize the data in this table and perhaps to put them in more usable form, we give the following summary (Table III) of the average insulated and average uninsulated home.

TABLE III
AVERAGE VALUES FOR TEN CONSUMERS

	Insulated Home Kw.	Uninsulated Home Kw.
1. Kw. connected load:		
A. Range	9.64	8.76
B. Water heater	5.70	6.25
C. Space heating	37.64	30.30
D. Totals	52.98	45.31
2. Kw.-hr. used annually for all purposes	17,758	20,796
3. Annual cost for all purposes	$383.74	$444.03
4. Annual cost for purposes exclusive of heat	267.06	319.47
5. Annual cost chargeable to heating	116.68	124.56
6. Cost per kw. of connected heat load	3.10	4.11

If we compare this cost of $3.10 per kw. with that of $4.11 per kw., it is readily seen that there is an economy of $1.01 in favor of insulation, or that failure to insulate will increase fuel cost by 32 per cent.

In many cases the necessary installed capacity can be reduced, when a house is effectively insulated. We have known of cases where the reduced cost of heaters and wiring, made possible because of insulation, was nearly enough to cover the added cost of insulation.

This would mean that insulation did not cost anything. It is always safe to say that insulation is an excellent investment and pays good dividends in economy, comfort and health.

*Electric Refrigeration**

Satisfactory support from electric utilities and refrigeration distributors in most sections of this territory have made this a year of considerable progress in this field.

* Report of refrigeration committee, merchandising bureau, Commercial Section. O. R. Doerr, chairman. G. W. Shane, vice-chairman. Oscar Clifford, Ivan de Jongh, R. Downing, Gaby Little, A. E. Morrison, E. Pierce, Howard Rector, George Buck.

Utility Support

THE subcommittees charged with the responsibility of soliciting utility support of the national refrigeration plan have completed this work with commendable results.

In the state of Arizona, utilities are doing a splendid work in cooperation with dealers. Practically every utility in this area is supporting the effort through newspaper advertising and special exhibits. The work in this state is in charge of A.E. Morrison of the Tuscon Gas, Electric Light and Power Company.

The state of Nevada, which carries the outstanding record in this division for 1931, has again reported pledges from utilities in that state for even greater cooperation in 1932. This subcommittee is headed by Oscar Clifford of the Sierra Pacific Power Company.

In the northern California area, the Refrigeration Bureau is particularly active and is being substantially supported by the utilities. Their efforts last year resulted in a better than 50 per cent increase in household refrigerator sales and a very satisfactory increase is anticipated this year. The chairman of the P.C.E.A. refrigeration committee is personally in charge of this area.

A similar optimistic report is coming from the southern end of the state, the area centering around San Diego, where the Bureau organization is functioning smoothly and utility support is ample. Sales from this section are expected to exceed those of last year.

The San Joaquin Valley section, headed by R. Downing of the Valley Electric Supply Company, also reports a functioning organization carrying on a refrigeration drive, amply supported by the utility subsidiary, the Valley Electric Supply Company.

In the southern area centered about Los Angeles, refrigerator distributors are well organized and are doing an excellent job. Sales for 1932 are well under way in this section and, from preliminary reports, it seems safe to predict that 1932 will witness a greater accomplishment here than did last year.

Refrigeration Bureaus

Work is progressing in the direction of formation of new local refrigeration bureaus throughout this geographic sec-

tion. A copy of the by-laws of the Northern California Refrigeration Bureau is attached.

Special Sales Plans

Special refrigeration campaigns and sales plans have been adopted in several subdivisions of this geographic section, involving the joint activity of utility, distributor, and dealer in the sale of electric refrigerators.

Sales Reports

In some sections very complete reports of sales are being accumulated for the information and guidance of distributors and dealers.

Pacific Coast Electrical Bureau Handbook

The revised article for this publication has been completed and submitted to the chairman of the Commercial Section, P.C.E.A.

The summary of the cooperative refrigeration program adopted by the northern California Electric Refrigeration Bureau is typical of the activities being sponsored in many other sections of this region.

BY-LAWS OF THE NORTHERN CALIFORNIA ELECTRIC REFRIGERATION BUREAU

Article I—

The name of this organization shall be: The Northern California Electric Refrigeration Bureau.

Article II—

The purpose of this organization shall be:

1. To promote a better understanding among the wholesalers and dealers in electric refrigeration in northern California; i.e., that territory which comprises the system of the Pacific Gas and Electric Co.

2. To work out and adopt policies for conducting refrigerator sales which shall be to the best interests of customers, dealers, wholesalers, and the utility.

3. To promote, finance, and execute plans which will stimulate the sale of electric refrigerators in this territory.

4. To maintain a permanent organization to conveniently and effectively direct and execute the activities decided upon by the Bureau.

Article III—

1. The membership of this organization shall be confined to wholesalers or distributors, handling electric refrigerators known to be the products of a reliable manufacturer.

2. The membership shall be further limited to wholesalers or distributors who maintain a warehouse where electric refrigerators are stored, or at least a store where their products can be displayed to the public or trade.

3. All members of the Bureau besides charter members, shall be admitted through ballot, a majority vote of all members being necessary to elect.

Article IV—

1. The officers of this Bureau shall consist of: (a) chairman, (b) vice-chairman, (c) secretary-treasurer.

2. The administration of the Bureau's affairs shall be handled by three general committees:

(a) An executive committee, comprised of the chairman and four other members elected by a majority vote of the membership.

(b) An advertising committee of three members appointed by the chairman.

(c) Finance committee, comprising three members headed by the secretary-treasurer. The two additional members to be appointed by the Bureau chairman.

3. The duties of the chairman shall be those which usually devolve upon an officer of this character. In the absence of the chairman, the vice-chairman shall assume the duties of the chairman.

4. The duties of the secretary-treasurer shall be to keep minutes of all meetings of the Bureau; to keep the records of receipts and disbursements of Bureau funds; to prepare a monthly statement of receipts and expenditures for the benefit of Bureau members; to send out bulletins or notices of meetings to members and to perform such other duties as the chairman may direct.

5. All moneys payable to the Bureau shall be maintained in a bank account under the name of the "Northern California Electric Refrigeration Bureau," and funds will be disbursed from this account by means of the joint signatures of the chairman and secretary-treasurer of the bureau.

6. The officers shall be elected by majority vote of the membership.

7. The term of office shall be for a period of one calendar year.

8. Representatives of a majority of the firms belonging to the Bureau shall constitute a quorum at any regular or special meeting.

9. Each member firm or organization shall be entitled to one vote.

Article V—

1. There shall be no initiation fee and no dues attached to membership in this Bureau other than the subscription decided upon by the Bureau to defray the expense of the activities contemplated for each year.

2. The Bureau shall be operated and conducted as a non-profit organization.

Article VI—

1. Regular meetings will be held at least once every two months at a date to be determined by the chairman. Special meetings may be called at any time at the discretion of the chairman. The chairman shall call a meeting at any time at the request of five or more members.

2. The secretary shall notify each member in advance of the date of the meeting.

Article VII—

1. Any member who may wish to do so shall have the privilege of resigning his membership in this Bureau by giving written notice to the secretary of his desire to withdraw. The resignation of any member will not result in reimbursement of any funds which he may have contributed to the Bureau for general advertising promotional work.

2. Any member or firm not represented at least at two of the stated meetings of the Bureau each year shall be automatically dropped from membership.

Article VIII—

1. Any member who in the opinion of the majority of the other members does not conduct his business according to the policies which have been adopted by this Bureau, and who, after having the matter called to his attention, continues to violate these policies, may be expelled by a two-thirds vote of the membership. All charges against any member, if any, should be preferred in open meeting and an opportunity shall be given him to defend himself before the members.

Article IX—

1. This Bureau may be dissolved by a two-thirds vote of the membership.

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*Water Heating**

Steps have been taken to eliminate the advertising of substandard appliances and a chapter on water heating has been completed for the home electrification manual. A number of recommendations are made by the committee for continued study.

EARLY in the year the committee recommended that steps be taken to eliminate, as far as possible, advertising and promotional activity for the faucet-type water heaters. Our latest information in this regard is to the effect that the *Saturday Evening Post* will discontinue the fostering of such advertising, which is misleading in its scope and detrimental to the sale of the legitimate type of electric water heaters.

The chapter on water heating for the book on home electrification was approved some time ago in its completed form.

The committee has discussed at some length the following subjects which, as they have not been completed, it passes on to the new water heating committee for continued discussion.

1. This committee believes that some consideration should be given to the compensation of utility salesmen, with the idea of adopting a compensation plan based upon revenue produced from a particular appliance, rather than upon the selling price of the machine or solely on the connected load. Due to the very desirable load-characteristics and revenue-producing ability of the water heater, we feel that preferred consideration should be given this appliance and that some such compensation method should be adopted.

2. The committee also has pointed out the desirability of encouraging employees of all companies engaged, either directly or indirectly, in the sale of electric water heaters, to use them in their respective homes, so that they may acquire a more thorough knowledge of the appliances we have for sale.

3. A suggestion has been made to the Red Seal committee that the attention of readers of Red Seal literature should be called to the necessity for a proper plumbing installation for

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* Report of the water heating committee, merchandising bureau, Commercial Section. C. F. Allen, chairman. R. E. Bacon, G. T. Bigelow, O. S. Clifford, A. V. Cline, R. W. Downing, H. J. Drexel, H. Fogwell, G. V. Footman, A. W. Krueger, Alfred May, J. D. Mercer, Frank Moon, E. B. Pierce, H. C. Rice, Carl Rohr, C. A. Russell, A. Strauch, L. S. Tudor, A. A. White.

electric water heaters. This deals principally with the recommendation for adequate installations of hot water pipes. The committee has found many instances where hot water pipes have actually been laid through cement foundations without any thought of proper insulation. This, as you know, encourages high operating costs, which are, in turn, detrimental to the successful operation of this appliance.

4. The committee also recommends that further study be given to the establishment of electric rates for water heating of a more competitive nature than those we now have. This consideration is quite important because of the inroads which have been made by natural gas.

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*Wiring Sales**

The work of the wiring sales committee this year was devoted largely to the national aspects of the problem, which left little time for carrying out the ambitious program outlined at the beginning of the year. This is left as a heritage to the incoming committee.

BOTTLENECK, both to consumer and to the electrical industry, is wiring. For the consumer, wiring restricts the service available from the use of electricity. To the industry, it establishes the limits for the number and kind of appliances to be sold or of the energy to be delivered through the meter.

And so wiring, the physical highway system for electrical energy from maker to user, has received more thoughtful attention this year than in many years past. Drastic reductions in new building volume have accentuated this interest. Naturally manufacturers, wholesalers, and contractors, because of non-existent new construction, have been given a more acute realization that wiring is primarily a means of livelihood and not, as with the Italians at San Francisco's Marina, a cheese which is great fun to roll.

In these reformed times, cheese is decidedly to be eaten, provided one can procure it, even. The days when it could be rolled in competition with other cheeses for high speculative stakes belong to the over-production era known as "the good old days." Likewise with wiring. It is definitely a means of livelihood to the manufacturer of wiring materials, to the wholesale distributor thereof, to the contractor who undertakes to install it, and to the wireman whose skill is added to it to make it useful equipment for the consumer.

Yet more than to any of these, is wiring necessary to the utility. Wiring must deliver the utility's product. Hence its carrying capacity very definitely sets the limits of utility growth or usefulness. To the utilities this is a fact of lasting consequences.

Realization of this fact has brought into focus for immediate attention a subject which, throughout the comfortable years, has reposed in a generally fuzzy background among the sales resistances. Whereas for years the public could take its wiring or leave it alone, for all anybody really cared, no such "laissez faire" attitude can longer be tolerated by those who will eat or not, depending upon the taking or leaving alone, as the case may be.

Ambitious as the declaration of purposes of this committee was at the beginning of the year, the work has progressed but little. Early, the Pacific Coast Electrical Association committee, which this year had much doubling to do in other committees, had its entire attention drawn from local activities, to be concentrated upon national affairs whose consequences would involve the Pacific Coast industry. Chief of these were the preparation of a declaration of policy relative to N.E.L.A. attitude on wiring methods, wiring codes and wiring sales by the national wiring sales committee.

Necessarily, so fundamental a statement required careful weighing of each word and a no less clear definition of utility viewpoint relative to its honorable intentions in wiring.

A second national activity of local importance was the preparation of residential wiring adequacy standards by a joint industry committee headed by E. A. Brand, chairman of the N.E.L.A. wiring sales committee. How these standards, when published, would appear in relation to Pacific Coast Electrical Bureau Red Seal standards, was of real importance to those out here who have spent years and much of the industry's money in promoting the Red Seal plan.

Fortunately, the Pacific Coast Electrical Association was for the first time, represented at two of the national meetings. This in itself allowed for a closer personal understanding as to territorial problems and difficulties than correspondence would ever establish.

At the first meeting, in Cleveland, attended by George Rankin, (Nov. 9, 1931) the first drafts of both the wiring sales policy statement and likewise the residential wiring standards were roughly prepared. At the second meeting, attended by W. A. Cyr, in Buffalo (Jan. 20, 1932), for the preparation of the policy statement, and in New York (Jan. 22, 1932) for the residential wiring standards, the details of these statements and standards, respectively, were discussed.

To describe all of the details of these meetings, the attempts to balance judgment and correctly to define and word these documents, though interesting, would consume time and space unnecessarily.

At a later meeting, held in Chicago, (Mar. 21, 1932) the final draft of the N.E.L.A. wiring policy was approved by the national committee, the Pacific Coast Electrical Association withholding its vote until the statement of policy thus proposed had been submitted to the executive committee of the Association here for approval. This caution on the part of the wiring sales committee is occasioned only by the highly controversial nature of the entire involved subject of wiring. In a time when trade relations are so delicately poised upon individualistic points of view, and with relations between the wiring trades and manufacturers on the Pacific Coast generally satisfactory, this committee felt the need of public policy scrutiny on the final draft of the national wiring policy declaration before local approval.

This will devolve upon next year's committee. The lengthy correspondence and the extensive detail involved in carrying this work to a satisfactory conclusion must be turned over to a fresh and enthusiastic committee next year.

With the residential wiring adequacy standards, the Red Seal committee this year can report more progress. Contact with the national joint industry committee meant the revision of several details which might have caused confusion when the standards are eventually circulated widely in the West. These details have been adjusted so as not to conflict with California Red Seal standards. Thus the experience had with the national commercial lighting standards will be spared the Pacific Coast Electrical Bureau in this instance. In the latter, there were many variances in both units of calculation and in special provisions. When circulated widely in California, they caused great confusion in architects' offices, because they were at variance with the previously issued and already quite well-established commercial Red Seal specifications of the Pacific Coast Electrical Bureau. After much trouble, the national specifications were withdrawn and the Pacific Coast commercial Red Seal specifica-

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* Report of wiring sales and Red Seal committees, merchandising bureau. Wm. A. Cyr, chairman. A. I. Benedict, Stewart Cundiff, R. C. Dalton, J. O. Dillingham, Jack Hammond, P. H. Needham, E. B. Pierce, A. L. Pryor, H. C. Rice, R. M. Taylor, C. H. Thrane, R. R. Walbridge.

tions substituted, and a promise received from national headquarters that it wouldn't happen again.

Thus, with the residential wiring adequacy standards, this situation will be avoided.

These national aspects of the situation naturally withdrew all attention from the local committee's own program, which laudably set out to start work on the following objectives:

1. Study wiring needs of each appliance committee in order to arrive at an estimate of the amount of wiring considered adequate to serve that committee.
2. Study various wiring methods for possible economies.
3. Evolve a selling plan which will receive the support of the industry.
   (a) Red Seal for residential
   (b) Red Seal for commercial
   (c) Industrial wiring standards
   (d) Agricultural wiring plan (P.C.E.B.)
4. Evolve a rewiring program for old homes.
5. Obtain for this program the support and assistance of:
   (a) Contractor
   (b) Wholesaler
   (c) Manufacturer
   (d) Inspector.
6. Prepare a chapter on wiring needs of modern living for the P.C.E.B. manual or pamphlet.
7. Watch and report on national movements in wiring practice.
8. Coordinate in committee work with the technical joint committee for wiring on consumers' premises.
9. Prepare popular wiring talks for power company or other representatives to give to public meetings.
10. Sell the idea of adequacy to the commercial man by sound processes, so he will not make excuses for wiring but will regard it as a part of his opportunity.
11. Get estimates of how adequate wiring increases the value of a home.
12. Evolve novel sales stunts to attract attention to adequate wiring in the home.
13. Seek to inaugurate a national movement to simplify wiring materials, eliminate outmoded wiring methods, enlisting support of manufacturers, wiremen, contractors, wholesalers and Department of Commerce.
14. Promote stabilization in the wiring field by better control of contracting outlets, installation practice and standardization methods; in other words, improve the economics of electrical installation.

None of these are less needed than a year ago and might well be made a heritage of useful purpose, a challenge to the next year's committee on wiring.

It is unfortunate, though perhaps necessary, that the year had to be devoted entirely to clearing the decks, and not to any particular action in real sales promotion of wiring. So many years of effort have been given to the preparatory steps and as yet little or nothing has been done actually to sell wiring. In fact, wiring can be said to be the most unsold commodity, for its usefulness, of any in the whole sphere of commercial activity. In an electrical age this is a most surprising paradox.

In the final stages of this year's national wiring sales activity, there are portentous signs.

At the Chicago meeting a selling plan book for wiring, started on its way two years ago, was finally approved and will soon be forthcoming. The previews of this plan and book afforded the chairman of this Pacific Coast Electrical Association committee gave evidence that around it a real selling effort can soon begin. Details of this idea will also be completed next year.

Altogether, all signs point to 1932-3 as the real beginning of industry-wide activity to sell wiring at last.

REPORTS OF GENERAL POWER BUREAU[1]

*Agricultural Power**

The agricultural power committee this year completed two projects for inclusion in the agricultural power handbook. In addition, a central library of agricultural power material and a bibliography were commenced. The drafting of safety rules for use on the farm was undertaken. It is recommended that these activities be continued by the committee of next year.

EFFORTS of the agricultural power committee this year were centered on the following subjects:

Establishment of a Library

It was thought desirable to establish a library of reference material on the subject of agricultural power in some central location, such as the office of the managing director of the Pacific Coast Electrical Assn. at San Francisco. Under the able supervision of Prof. B. D. Moses, considerable material has been collected. The committee feels that this is an undertaking of considerable importance which cannot be completed in one year and recommends its continuance by next year's committee.

Compilation of Bibliography

Data toward a bibliography covering the subject of the use of power on the farm were collected. It is recommended that this activity be carried over into the coming year for completion.

Competitive Power

The committee contemplated the assembly of information on competitive power, directly applicable to agricultural power, but this project was dropped.

Agricultural Handbook

Four additions to the agricultural handbook were recommended. Of these, the compilation of a table of easy formulas for figuring water costs in pumping was completed and has been submitted for insertion in the handbook.

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[1] P. P. Pine, San Diego Consolidated Gas & Electric Company, chairman.
American Air Filter Company: F. W. Kolb.
American Air Blower Corporation: E. C. Cooley.
Arizona Edison Company: C. T. Yates.
L. H. Bennett Company: R. F. Pierce.
Booth Engineering Company: W. H. Sterling.
Buffalo Forge Company: J. G. Scott.
California Farm Bureau Federation: L. S. Wing.
Carrier Engineering Corporation: B. E. Dunn, J. F. Parks, L. H. Polderman.
Coast Counties Gas & Electric Company: F. D. Beardsley, R. C. Dalton.
Committee on Relation of Electricity to Agriculture: Prof. Ben D. Moses.
Crane Company: G. W. Nunn.
Electrical West: George Tenney.
Frigidaire Corporation: E. S. Riley.
General Electric Company: E. J. Cipperly, W. J. Delehanty, E. M. Ellis, Loys Griswold, H. C. Hill, C. R. Owens, M. Rhine, M. H. Schnapp, A. R. Tanner, E. E. Thomas.
General Electric Supply Corporation: C. H. Thrane.
Ilg Electric Ventilating Company: E. D. Price.
Los Angeles Gas and Electric Corporation: Karl Bennett, F. L. Moon, Jack Wells.
Minneapolis-Honeywell Regulator Company: N. A. Naylor.
Montgomery Bros.: Boyden MacFie.
Pacific Gas and Electric Company: G. W. Bernard, O. R. Doerr, A. M. Frost, R. I. Meyerholz, W. H. Park, D. C. Ray, W. C. Schafer, T. A. Wood, J. W. Wrenn.
San Joaquin Light & Power Corporation: J. P. Kastl, J. P. McElroy, DeWitt Scott, G. E. Zelhart.
B. F. Shearer Company: H. I. Tegtmeier.
Sierra Pacific Power Company: O. S. Clifford.
Southern California Edison Company Ltd.: C. L. Ashley, C. C. Bartlett, H. A. Brody, R. H. Cates, S. L. Cipperly, P. J. Denninger, A. W. Frost, C. E. Houston, R. C. McFadden, M. W. Phillips, H. C. Rice, C. C. Stewart, George Sullivan, W. E. Thompson, George Whitney, J. M. White.
The Southern Sierras Power Company: W. R. Chawner, D. B. Wheelock.
B. F. Sturtevant Company: G. P. Dickson.
Valley Electrical Supply Company: H. H. Courtright.
Wesix Company: H. V. Mooney.
Westinghouse Electric & Manufacturing Company: C. H. Brunner, J. H. Fenton, T. A. Reid.
Westinghouse Supply Company: Louis Berger.

* Report of committee on agricultural power, general power bureau, Commercial Section. J. P. McElroy, chairman. F. D. Beardsley, O. S. Clifford, W. J. Delehanty, A. M. Frost, Loys Griswold, Prof. Ben D. Moses, R. C. McFadden, M. W. Phillips, D. C. Scott, G. H. Sullivan, D. B. Wheelock, George Whitney, L. S. Wing, T. A. Wood, C. T. Yates.

The drafting of safety rules for use on the farm was assigned to a subcommittee which recommends that this activity also be continued by next year's committee.

The committee recommended that the managing director be instructed to obtain a sufficient number of reprints of "Why the Demand Charge" by L. S. Wing, engineer of the California Farm Bureau Federation, to be inserted in the agricultural power handbook.

It was proposed to compile a table of unit power requirements and costs for various electrical farm operations, but this project was dropped.

*Air Conditioning**

The preparation of a manual of a non-technical nature for use by power companies and others wishing to push this load has been the main work of the air conditioning committee this year.

THE committee investigated such information as was obtainable on this subject and found that while there was plenty of a technical nature in various publications and handbooks, the only information of a non-technical nature was that found in the advertising matter issued by the various manufacturers.

The technical treatises were comparatively complete and easily available to those interested, the non-technical information, however, was widely scattered and could only be secured from manufacturers whose location had in many cases to be ascertained from advertising appearing in trade magazines and from correspondence with power companies.

Correspondence with some 42 power companies showed that while the majority of them were interested in the possibilities of the air-conditioning load, only a few were actively engaged in its promotion, and this work was being done by technically trained men who cooperated with manufacturers, architects and engineers. The possibilities of this load were demonstrated by reports showing connected load secured by those who had established records for this purpose and who were active in its promotion.

Consideration was given by the committee as to how this load could best be promoted on the Pacific Coast, and it was decided that if all power salesmen and others who were not technically trained could be given sufficient information of a non-technical type to enable them to talk intelligently of the advantage of air conditioning, that these salesmen could develop many valuable prospects which could be referred to those handling the apparatus for final closing.

It was decided that the most feasible way of imparting the necessary information would be to prepare a primer or manual on air conditioning that would give the necessary information in such a manner as would be easily understood by anyone.

Having no precedent to go by, the committee members wrote articles which they considered suitable for the manual. Many of these articles were more or less technical and, while extremely valuable, had to be rewritten, resulting in the loss of considerable time. Every member of the committee, irrespective of location, has had an opportunity of reading the text of the manual, the majority of them have been present at meetings and each article has met with the general approval of the committee. Criticism has also been sought from persons, other than committee members, who were considered to be in a position to render assistance.

In its investigations the committee found that many partial applications of air conditioning could be made where entire installations were too expensive or not considered necessary, and has recommended that such also be given consideration.

The manual is divided into five sections, as follows:

(a) A general treatise on air conditioning with an illustration of a complete system and a short description of the apparatus.

(b) An amplified description of apparatus used, with explanation of its operation.

(c) Some possible prospects and the value to them.

(d) Drawing of another type of installation, showing alternative use of ice instead of mechanical refrigeration and line drawings of apparatus.

(e) Photographic illustrations of buildings using air conditioning wholly or in part, with connected load, also showing some interior installations.

The manual will be ready for distribution at the convention in June.

* Report of air conditioning committee, general power bureau, Commercial Section. J. W. Wrenn, chairman. F. L. Moon, vice-chairman. A. V. K. Babcock, R. A. Brobeck, R. H. Cates, E. C. Cooley, R. C. Dalton, F. W. Devers, G. P. Dickson, Berry E. Dunn, H. T. Goshon, F. W. Hook, F. W. Kolb, Geo. H. Linsley, Jr., J. Laichinger, H. L. Lincoln, Boyden MacFie, R. I. Meyerholz, H. V. Mooney, N. A. Naylor, G. W. Nunn, L. H. Poldermann, J. F. Parks, W. H. Park, Chas. T. Phillips, E. D. Price, R. F. Pierce, E. S. Riley, W. H. Sterling, W. C. Schafer, J. G. Scott, H. I. Tegtmeier, E. E. Thomas, D. B. Wheelock, G. E. Zelhart.

*Industrial Heating**

The industrial heating committee this year confined its activities to cooperation with the programs of the Pacific Coast Electrical Bureau. No written report is therefore necessary.

* Report of industrial heating committee, general power bureau, Commercial Section. T. A. Reid, chairman. Karl Bennett, G. W. Bernard, E. J. Cipperly, S. L. Cipperly, C. R. Owens, J. M. White, G. E. Zelhart.

*Industrial Power**

The report of the general power committee this year consists of additional data to be included in the industrial power handbook issued by the Pacific Coast Electrical Bureau.

THE work of the committee on industrial power during the past year has consisted in the compilation of data for inclusion in the Industrial Power Handbook. The present costs of equipment are changing so rapidly that we are able to report only on operating data covering equipment which has been installed and operated for a number of years. The figures have in large measure been abstracted from current magazines and should represent very accurate data.

It is the recommendation of the present committee that the assembling of this information be continued and that more data be gathered, if possible, on existing installations in California. It is our belief that with the decreasing cost of Diesel engines and decreased cost of fuel and lubricating oil, there will be increased competition from Diesel equipment in California.

* Report of general power committee, general power bureau, Commercial Section. W. H. Park, chairman. C. L. Ashley, H. A. Brody, C. H. Brunner, W. R. Chawner, E. M. Ellis, C. E. Houston, J. P. Kastl, J. P. McElroy, M. Rhine, M. H. Schnapp, W. E. Thompson, Jack Wells.

OPERATING EXPENSES

Items of Cost	Proper Amount to be Charged	Amount Usually Listed by Proponents of Isolated Plants
Fuel and Water	Actual cost plus cost of handling, storage and wastage.	The net amount of the bill for electric fuel, oil, gas, etc., but not water.
Lubricating Oil	Actual cost plus handling, storage, reclaiming and wastage.	The purchase cost f. o. b. delivery point only.
Maintenance and Repairs	Actual cost of repair parts in place or in stock, reconstruction work, painting and general upkeep. Should be about 3 to 3½ per cent of total cost of plant in place.	Usually the purchase cost of repair parts f. o. b. manufacturer's shops, such as some one can conveniently remember. Frequently assumed at 1½ to 2 per cent of f. o. b. factory cost of only principal items of equipment most used.
Attendance Labor	Actual cost of all labor, plus allowance for sickness, vacations, overtime, employees' liability, insurance, medical attention, etc.	Usually part or all of the base salary of the direct labor only.
Supervision, Salary and Expenses	The proportion of time and expense of management supervision. It should include a proportion of legal expenses.	This item never included and usually not considered as existing.
Miscellaneous Charges	The total of all incidental costs directly chargeable to power plant but not previously specified.	Never recognized as an item and usually nothing included.
Auxiliary Power Service	The cost of standby power and light, whether or not it is used.	This item never mentioned and seldom considered.

The Cost of Operating an Isolated Plant

The cost of power in any plant consists of operating expenses and fixed charges. Operating expenses will vary with the load and according to the number of hours operated per day. Fixed charges are nearly constant, depending upon the total cost to install and the probable life of the plant.

Steam Power Generation

Modern industrial plants, which require large amounts of low-pressure steam for process work, may present an opportunity for the installation of some steam-driven electric generating equipment, provided they have:

1. Ample boiler capacity.
2. Boilers capable of generating steam pressure suitable for the operation of modern engines and turbines.
3. Low-pressure steam demands that occur at the same time that electric loads occur.
4. Sufficient amount of low-pressure steam requirements to justify a suitable water rate. All waste heat should be fully utilized.
5. Sufficient savings to cover fixed charges and additional operating costs, such as increase in fuel, labor and supplies.
6. Ample space available (space costs money).
7. The proper rate schedules available to purchase additional power requirements, including break-down and emergency service.
8. Flexibility of operation with a combination plan that allows for seasonal operating requirements.

The final over-all costs with the operation of an isolated plant, or the combined plan of purchased power and generated power, should be less than the cost of purchasing all power. Any combined plan of power generation and purchased power should take care of future requirements and not lose the flexibility features of purchased power.

Heat Power Survey

In attempting to determine the heat and power balance in an industrial plant, the first step should be a careful survey involving accurate measurements of all heat and power requirements. Many modern engineers recommend the use of a steam flow diagram, showing steam pressure and pounds of steam required. It is also necessary to show quantity and temperature of condensate returned to the boilers. A record showing the time of maximum requirements for steam and electric power is very essential.

Heat Power Ratio

In order to give a preliminary estimate as to whether or not a balance of heat and power can be properly worked out, and along the proper lines, it is essential to determine the over-all *heat power ratio.*

$$\text{Heat power ratio} = \frac{\text{Total process heat required (B.t.u.)}}{\text{Total kw.-hr.}}$$

$$= \text{B.t.u. available per kw.-hr.}$$

TYPICAL HEAT POWER RATIOS

Plant	Exhaust Temp. Fahr.	B.t.u. per kw.-hr.
Non-condensing	212°	30,000
Condensing	90°	16,000
Diesel engine	700°	10,000

To simplify calculations for preliminary estimates, the following charts have been prepared. These charts show at a glance the necessary initial steam conditions to give any quantity of power from a known amount of process steam.

Chart I is based upon the ideal engine using the Rankine cycle. In order to arrive at actual operating conditions, certain efficiencies must be taken into consideration.

The two main types of steam power generating equipment, turbines and engines, have very different operating characteristics. The efficiencies of turbines do not vary greatly over various pressure ranges. Turbines below 1,000 kw. decrease rapidly in efficiencies with decreasing sizes, while larger turbines have higher efficiencies.

Efficiencies of reciprocating engines vary much more than those of turbines. When small engines are in good condition, their efficiencies exceed those of small turbines. A change in back pressure does not affect a steam engine as much as it would a turbine.

Maximum efficiencies are generally reached near or above three-quarter load.

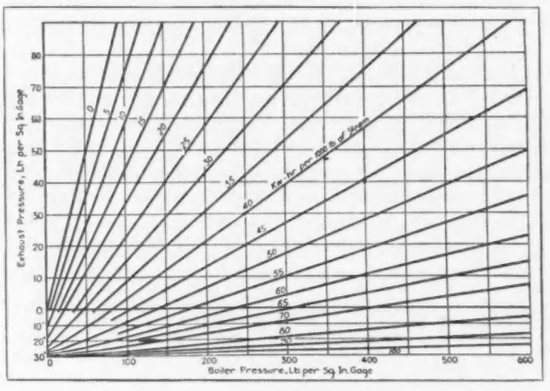

Fig. 1—Power developed by ideal engine for various steam conditions

TURBINE AND ENGINE EFFICIENCIES TO BE USED WITH IDEAL ENGINE CURVES

Turbine Efficiency (per cent)—

Small (under 1,000 kw.)—40 to 60
Large (over 1,000 kw.)—50 to 85

Engine Efficiency (per cent)—

Small (under 500 hp.)—50 to 70
Large (over 500 hp.)—50 to 80

In calculating the over-all efficiency of a generating unit, it is also necessary to consider the generator efficiency, which should be near 95 per cent.

EXAMPLE CASE OF FIG. 1

Find the water rate of a 200-kw. turbine operating under 150-lb. gage boiler pressure and a 5-lb. gage back pressure.

(a) Choose ideal power output at intersection of 5-lb. horizontal and 150-lb. vertical lines, which is 45 kw.-hr. per 1,000 lb. of steam, or

$$\frac{1{,}000}{45} = 22.2 \text{ lb. per kw.-hr.}$$

(b) Use turbine efficiency of 60 per cent and generator efficiency of 95 per cent. Therefore

$$\text{Water rate} = \frac{22.2}{0.60 \times 0.95} = 39 \text{ lb. per kw.-hr.}$$

(c) The corresponding kw.-hr. per 1,000 lb. of steam will be $45 \times 0.95 \times 0.60 = 25.7$ kw.-hr.

The heat available per pound of steam, which governs the water rate of the engine or turbine may be increased by:

1. Increasing initial boiler pressure.
2. Superheating the steam.
3. Decreasing the back pressure.

BOILER DATA

There are numerous boiler classifications, the more common being classed as internally and externallly fired, water-tube, fire-tube and return-tubular, horizontal and vertical boilers.

The internally fired boilers are: vertical, tubular, locomotive, Scotch Marine and flue boilers. The externally fired boilers include plain cylinder and return-tubular and water-tube boilers.

Unit of Evaporation—

Boiler performance is commonly expressed in terms of weight of water evaporated per pound of fuel, or

TABLE 1. TYPICAL PERFORMANCE DATA ON ENGINES PLACED IN SERVICE TEN OR MORE YEARS AGO[1]

	Steam Pressure	Exhaust Pressure	Steam Rate Lb. per 1 hp.	Steam Rate Lb. per Kw.-Hr.
Tandem compound engine; high-pressure, slide-valve; low-pressure, rotary-valve, 100-kw	94	Atmos.	51	83.8
Single-cylinder riding cutoff piston-valve engine, 200-kw	102	Atmos.	28.8	50.6
Single-cylinder piston-valve engine, 75-kw.	92	3 lb.	39.5	63.0
Single-cylinder piston-valve engine, 150-kw	103	Atmos.	37.3	37.3
Single-cylinder pressure-plate valve, 100-kw	125	Atmos.	53.9	89
Pressure plate valve engine, 75-kw	105	2 lb.	51	84
Two-valve uniflow with poppet valves, 150-kw	132	Atmos.	26.5	42.6
Corliss non-releasing gear engines, 230 hp.	92	9.5	38.2*	....
Corliss non-releasing gear engines, 140 hp.	95.5	5	45.5*	....
Corliss non-releasing gear engines, 200 hp.	143	23	....	45.4

*Including boiler feed pump.

[1]Courtesy *Power Plant Engineering.*

FIXED CHARGES

Items of Cost	Proper Amount to be Charged	Amount Usually Listed by Proponents of Isolated Plants
Interest* on Invested Capital	The total cost of borrowing or holding money including the cost of establishing credit, floating bonds, discounts, etc. Should never be less than 6 per cent.	Usually included at the lowest prevailing rate of interest on money actually borrowed only, nothing more.
Depreciation due to use, obsolescence, inadequacy, or dissatisfaction with use	Amount set aside should be based on a reasonable weighted average useful life of all of the equipment, buildings, and facilities involved in power production. Should range between 5 and 10 per cent.	Sometimes, but not always, included at much too low a figure.
Insurance	Should include actual or prorated cost of fire, tornado, water, and other forms of protection or operating insurance. Should never be less than one per cent of complete cost of plant in place.	Seldom included, especially where equipment is bought on a so-called savings basis.
Taxes	Proper proportion of all government, state, county, city and corporate taxes actually paid. Should never be less than 1½ per cent of the cost of plant in place.	Seldom included, especially when equipment is bought on a so-called savings contract.

*Investment should include the engineering and supervision to plan and install the power facilities.

TABLE II. DATA ON MODERN TYPES OF STEAM ENGINES†

Type, Size and Operating Condition of Engines	Cylinder Dimensions Inches	I. Hp.	Initial Pressure Lb.	Back Pressure Gage	Full Load M. E. P.	R. P. M.	Lb. Dry Steam Per I. Hp. per hr.	Rankine Cycle Efficiency %	Lb. Dry Steam per Kw.-hr.
100 Kw.	15x16	160	100	0	43.7	260	28.9	58.7	46.2
	12x16	160	150	0	68.6	260	25.0	58.0	40.0
Single Valve 500 Kw.	29x32	800	100	0	50.5	150	26.9	63.1	43.1
	24x32	800	150	0	74.0	150	23.3	62.2	37.3
100 Kw.	15x16	160	100	0	47.2	240	23.3	72.8	37.3
	11x16	160	175	0	88.7	240	19.4	70.7	31.1
Four-Valve (Corliss) 300 Kw.	23x28	480	100	0	50.2	165	22.4	75.6	35.9
	17x28	480	175	0	92.7	165	18.6	73.8	29.8
750 Kw.	32x36	1,200	125	0	66.4	135	20.1	77.2	32.2
	27x36	1,200	175	0	93.7	133	18.0	76.2	28.8
100 Kw.	16x16	160	100	0	39.8	250	21.8	77.8	34.9
	11x16	160	225	0	85.1	250	16.8	75.1	26.9
Poppet Valve (Uniflow) 300 Kw.	26x24	480	100	0	37.6	200	20.8	81.5	33.3
	17x24	480	225	0	89.0	200	16.0	78.8	25.6
750 Kw.	33x36	1,200	125	0	58.6	133	18.6	83.4	29.8
	25x36	1,200	225	0	102.6	133	15.5	81.4	24.8
300-Kw. Simple (Corliss)	18x30	475	150*	0	82.	150	21.7 ¾ L	65.6	
300-Kw. Uniflow	20x22	475	175*	0	68.	200	15.6 ¾ L	87.7	
300-Kw. Uniflow	20x22	475	175*	26 in. V.	68.	200	10.8 ¾ L	79.	

†Courtesy *Power Plant Engineering.*

*No Moisture.

TABLE III. PERFORMANCE OF MODERN ENGINES UNDER VARYING CONDITIONS*

Type	Cylinder Bore in Stroke in Inches	I HP.	Initial Pressure of Superheat Back Pressure or Vacuum	M. E. P.	R. P. M.	Net Lb. Per I. Hp.-hr.	Rankine Cycle Efficiency %
9652	23x30	73	166–024.1	9.8	120	12.74	72.9
Emergency Fleet	23x30	283	161–0–23.8	38.5	119	14.27	66.2
Corporation—Horizontal	23x30	79	162–57°–24.9	10.58	121	11.33	77.5
Uniflow	23x30	314	162–55°–24.1	42.22	120	12.99	66.7
Steam-tight Poppet	23x30	75	163–112°–24.2	9.93	120	11.67	74.0
Valve Cam-actuating	23x30	296	164–109°–24.2	39.92	120	12.30	69.5
Gear	23x30	92	166–154°–24.2	12.43	120	9.24	87.0
Gear	23x30	333	161–158°–24.2	45.23	119	11.22	72.0
10346	24½x32	255	132–0° –0	28.5	123	17.9	85.8
American Locomotive Co.—Horizontal	24½x32	275	164–0° –0	30.5	124	16.8	84.2
American Locomotive Co.—Horizontal	24½x32	298.5	161–31° –0	33.4	123	16.4	85.0
Uniflow	24½x32	307.5	168–101°–0	34.1	124	14.5	88.8
Steam-tight Poppet	24½x32	264	169–138°–0	31.8	123	13.6	92.4
Valve Cam-actuating Gear	24½x32	268.5	163–135°–26 in. V.	29.8	124	10.2	77.6
11057	19x20	316.5	250–200°–26½ in. V.	40.3	93	8.70	78.9
11058	19x20	700	250–211°–26½ in. V.	60.5	136	9.35	72.5
Standard Unit Navigation Co.—3-Cylinder Vertical—Steam-tight Poppet Valve Cam-actuating Gear.							
10305	21x24	253	155– 0°–0	31.95	197	17.58	82.2
Teachers' College	21x24	190	156– 0°–0	23.90	198	17.74	81.6
Horizontal Uniflow	21x24	120	155– 0°–0	15.06	199	18.39	78.8
Steam-tight Poppet Valve Cam-actuating Gear.		311	155– 0°–0	39.20	197	17.70	81.7

*Courtesy *Power Plant Engineering.*

the weight of water evaporated per square foot of heating surface. The heat required to evaporate one pound of water at 212 deg. F. into saturated steam is called a unit of evaporation and equals 970.4 B.t.u.

$$F = \frac{\text{Heat Content in Steam} - (\text{Feed water temp. deg. F} - 32)}{970.4}$$

Heating Surface—

All parts of the boiler which are covered by water and subject to the hot gases are considered heating surface. The mean value for evaporation should give from 3 to 4 lb. of water evaporated per sq. ft. of heating surface at normal rating; therefore, each boiler horsepower requires from 9 to 11 sq. ft. of heating surface at normal rating.

STEAM TURBINE DATA
STANDARD NON-CONDENSING—
80 PER CENT POWER FACTOR

Kw. Rating	Voltage Range	Initial Pressure lb.	Water Rates—lb. Full Load	Water Rates—lb. Half Load	Cost Dollars	Dollars Kw.
55	240/2,300	.....	...	...	$ 3,580	$65.00
75	240/2,300	.....	...	...	4,450	59.40
100	240/2,300	150–16	67	78	6,875	68.75
100	240/2,300	150– 4	52	61	6,875	....
100	240/2,300	200– 4	48	56	6,875	....
200	240/2,300	150–16	62	73	8,175	40.75
200	240/2,300	150– 4	48	57	8,175	....
200	240/2,300	200–16	55	65	8,175	....
200	240/2,300	200– 4	44	52	8,175	....
300	240/2,300	150–16	59	70	8,475	28.20
300	240/2,300	150– 4	47	55	8,475	....
300	240/2,300	200–16	52	61	8,475	....
300	240/2,300	200– 4	42	50	8,475	....
500	480/2,300	150–15	48.4	55	18,700	32.40
500	480/2,300	150– 4	39	44	18,700	....
500	480/2,300	200–15	42.7	50	18,700	....
500	480/2,300	200– 4	36	41	18,700	....
600	480/2,300	150–15	47.6	54	20,100	33.80
600	480/2,300	150– 4	38.7	43	20,100	....
600	480/2,300	200–15	42	47	20,100	....
600	480/2,300	200– 4	35.5	90	20,100	....
600	480/2,300	250–15	40	44	20,100	....
600	480/2,300	250– 4	33	37	20,100	....
750	480/2,300	200–15	41.4	45.5	23,000	30.60
750	480/2,300	200– 4	35	38	23,000	....
750	480/2,300	250–15	38	42	23,000	....
750	480/2,300	250– 4	33	36	23,000	....
750	480/2,300	300–15	35.9	40	23,000	....
750	480/2,300	300– 4	31.6	35	23,000	....
1,000	480/2,300	200–15	40.8	44	27,400	27.40
1,000	480/2,300	200– 4	34.6	38.8	27,400	....
1,000	480/2,300	250–15	37.5	40.6	27,400	....
1,000	480/2,300	250– 4	32.5	34.8	27,400	....
1,000	480/2,300	300–15	35.2	38.4	27,400	....
1,000	480/2,300	300– 4	31.1	33.6	27,400	....
1,250	480/4,100	200–15	40	43	31,200	25.00
1,250	480/4,100	200– 4	34.3	36	31,200	....
1,250	480/4,100	250–15	37.1	39.7	31,200	....
1,250	480/4,100	250– 4	32.3	34.1	31,200	....
1,250	480/4,100	300–15	34.9	37.5	31,200	....
1,250	480/4,100	300– 4	30.8	32.7	31,200	....

Horsepower of Boiler—

A boiler horsepower is equivalent to the evaporation of 34.5 lb. of water per hour at 212 deg. F. to steam, at atmospheric pressure. (34.5 x 970.4 = 33,479 B.t.u. per hour.)

The boiler horsepower necessary to supply steam to an engine or turbine depends on—

(a) Steam rate (lb. per hp.-hr.) or (lb. per kw.-hr.).
(b) Per cent rating the boiler is to be operated under.

It is common to find the boiler operated at 150 to 200 per cent normal rating, and in extreme cases up to 400 per cent normal rating. The ratio of boiler horsepower to kilowatt generating capacity in usual cases varies from 1 to 4 (i.e., 1 boiler horsepower may supply 1, 2, 3 or 4 kw., depending on per cent rating of boiler and steam rate of generating unit).

Boiler Efficiency—

The boiler efficiency is the ratio of heat absorbed (B.t.u.) to the heat supplied in the furnace (B.t.u.). This efficiency should be between 70 and 80 per cent. Under normal operating conditions found in industrial plants, the most efficient operations occur with 150 to 200 per cent normal rating.

Furnaces—

As most of the boilers on the Pacific Coast are fired with either oil or natural gas, only these fuels will be considered. The modern practice requires at least one cubic foot of furnace volume per rated boiler horsepower. Mechanical oil burners are made in various sizes and should be supplied with hot oil (180 to 200 deg. F.) and operated at pressures from 60 to 100 lb. gage pressure. The heat content of oil averages near 18,500 B.t.u. per lb. The pressure used on natural gas burners varies from 4 oz. to a maximum of 10 lb.

STEAM ENGINE COSTS ON PACIFIC COAST

Cap. Kw.	Pressure Range—Lb.	Water Rate—Lb. per Kw.-hr.	Engine Costs F.O.B. East	Remarks
100.....	100–0	38–40	$7,000	.....
150.....	150–0	38–40	8,900	.....
175	150–0	35–38	15,000	Uniflow Engine
200.....	150–0	35–38	12,000	.....
300.....	150–0	31–35	18,000	.....

Installation Costs:
Concrete.....$16 per yard in forms
Hauling and Rigging..... 15 per ton

Furnace volume and draft conditions govern the burner pressure. The heat content of natural gas varies from 1,000 to 1,800 B.t.u. per cu. ft.

Boiler Costs

Present day steam boiler prices for new standard equipment as quoted on the Pacific Coast will generally be near the following prices:

Boiler, Stack, Brick work, Burners—25 to 100 boiler horsepower @ $50 per hp. rating.

If there are two boilers, the piping costs will run near $1,500. Feedwater heater and pump can be secured for $700.

In larger sizes the prices per rated hp. decrease.

100 to 200 hp.—@ $40 per boiler horsepower.
200 to 500 hp.—@ $35 per boiler horsepower.

With piping for two boilers, add $3,000 and for feedwater heater and boiler pump, add $1,200.

Present day second-hand boilers are generally quoted f.o.b. present location and average near $6 per rated hp.

To this cost must be added

$ 2.00 per hp. for removal.
10.00 per hp. for reerection of brick work.
3.00 per hp. for stack and furnace costs.

Present new boiler costs are so attractive that few old boilers are reerected.

Diesel Engine Report

The Diesel engine developed in 1890 has become quite a factor in power production, being chiefly used in the marine field. Between 1920 and 1930, the total capacity installed in this country increased from 2,000,000 hp. to 6,000,000 hp. The chief sales were made through the Middle West where the communities do not have the advantages of an interconnected hydro-electric system, such as is found on the Pacific Coast. The horsepower installed per year has steadily decreased since 1928, when 425,000 hp. was installed. During the year 1931 there was only 300,000 hp. installed in the United States.

The present trend of engine manufacture is toward the acceptance of the two-cycle engine, employing solid or mechanical injection principles. Today's manufacturers are employing higher rotative speeds, which decrease the weight per horsepower of the engine. The fuel-oil consumption for average quotations has decreased from 0.52 lb. per brake-horsepower in 1920 to 0.42 lb. per brake-horsepower in 1931. The present day fuel-oil economy has closely approached the expected thermal efficiency and will probably be reduced very little with new engine developments. The lubrication-oil consumption is dependent upon many variables, but well maintained plants should enjoy 2,000 b.hp.-hr. per gallon. (This figure is independent of load on engine and is the product of rated horsepower and hours of operation.)

Present day operators are beginning to realize the necessity for treatment of cooling water. Water containing calcium and magnesium salts forms precipitates in the engine jackets and decreases the engine efficiency. This subject should be treated very carefully with the installation of large plants, where large amounts of cooling water are necessary.

Recent reports prepared by the A.S.M.E. show that the majority of plants employing Diesel electric power generation average between 9 and 11 kw.-hr. per gallon of fuel oil, and that the better plants receive 1,500 kw.-hr. per gallon of lubricating oil, but that a better figure based upon kilowatt-hours at the switchboard would be near 1,000 kw.-hr. output. An inspection of the recent A.S.M.E. report shows that engine maintenance, plus repairs, will average between $1.50 and $2.00 per engine-horsepower-year for parts and that labor accompanying the installation of these parts must be added to this figure. Many plants show an average of 2 mills per kw.-hr. for repairs and parts supplied. An inspection of many plants in operation shows that best economies occur when the engines are operated at approximately 80 per cent of rated capacity.

Prices quoted on the Pacific Coast today for engine and air-starting units, f.o.b. San Francisco or Los Angeles, vary from $70 per hp. for a 30-hp. engine to $50 per hp. for a 500-hp. engine. The cost of additional equipment, such as mufflers, fuel-storage tanks, water-circulation pumps, must be added to these quotations. Present day installation costs will be approximately $16 per cu. yd. for concrete foundations, $1 per ton-mile for hauling and from $2 to $6 per hp. for installing. An ordinary galvanized iron building for housing industrial and agricultural installations may be constructed for from $2 to $4 per hp.

The cost of installing a Diesel engine generating plant, including engine, generator and auxiliaries, completely installed in a suitable building, will be between $100 and $125 per kw. of rate capacity.

The price on fuel oil on the Pacific Coast depends entirely upon the locality. The present day price for suitable fuel oils, where the gravity ranges between 24 and 30 Baumé, is $1.26 per bbl. for tank car delivery on standard railroads, and about $1.68 to $1.75 per bbl. for truck delivery of 1,000 gal. A good quality of lubricating oil can be purchased for from 40c to 50c per gallon.

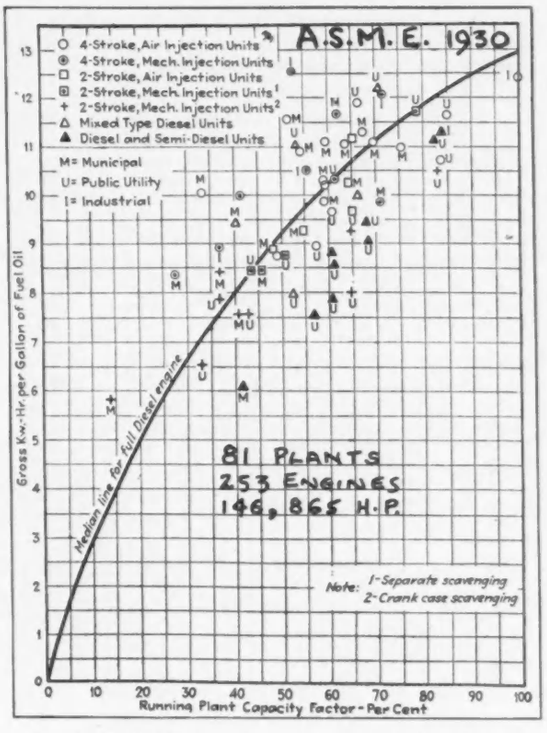

Fig. 2—Fuel oil consumption at various plant capacity factors—(Courtesy Power, Sept. 15, 1931)

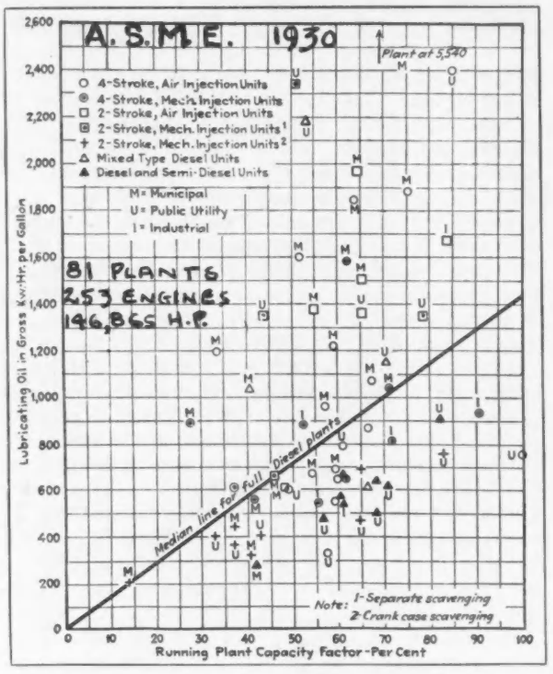

Fig. 3—Lubricating oil consumption—(Courtesy Power, Sept. 15, 1931)

Cost of Installing a 500-kw. Diesel Power Plant*

During the period from 1920 to 1929, Diesel engine power plants in capacities from 500 to 1,500 kw., including two units, could be installed for prices varying from $150 to $200 per kw. installed. Since 1929 and the beginning of the depression period, and because of Newark construction principles, the prices quoted for various jobs during 1930 decreased to as much as $110 per kw. A recent quotation for the installation of a 500-kw. Diesel plant, including one engine and one generator, is shown in the table below.

750-hp. modern-type Diesel unit, with lubricating system complete, fuel day tank, heater and strainer, exhaust muffler, tools, spare parts and anchor bolts, freight and services of an erecting man	$40,000
500-kw. generator and exciter delivered with engine	4,500
Switchboard control panel, with automatic voltage regulator and connecting cables and conduit	1,300
Piping for fuel, lubricating, starting air, cooling water, and exhaust	600
Fuel storage, 30,000 gal. with transfer pump	850
Labor for unloading, cleaning and assembling equipment ready for operation	800
Cooling tower, with basin and cooling-water pumps	950
Building of plain brick construction, fireproof, with glazed interior wall surface, including both building and machinery foundations, also I-beam with chain hoist and trolley over center line of unit	4,500
Plans, engineering, and general supervision of construction	4,000
Total Installation Cost	$53,600
Unit Costs — $107 per kw.	

It is interesting to note from another part of this article that fuel oil requirements were based upon 10.9 kw.-hr. per gallon of fuel oil and lubricating oil costs were based upon 985 kw.-hr. per gallon of lubricating oil. Maintenance and upkeep were estimated at $1.50 per hp. per yr., with an additional item of $150 for waste, grease and miscellaneous supplies.

* From *Power Plant Engineering*, Dec. 1, 1931.

PACIFIC COAST DIESEL ENGINE COSTS

B.Hp.	No. of Cycles	R.P.M.	Price Engine with Eqpt. "A"	Price Air Equipment "B"	Total Price Equipment "A" & "B"	Shipping Weight with Equipment "A" & "B"	$ Per Rated Hp.
30	2	600	$1,900	$240	$2,140	5,800	$71
45	3	600	2,550	240	2,790	7,200	62
60	4	600	3,200	240	3,440	8,400	57
80	4	450	4,300	240	4,540	12,000	57
120	6	450	5,940	240	6,180	15,500	52
110	4	360	5,760	275	6,035	20,000	55
160	6	360	8,120	275	8,395	24,000	52
135	4	327	7,100	275	7,375	22,500	55
200	6	327	10,000	275	10,275	29,600	51
180	4	300	10,200	275	10,475	36,500	58
275	6	300	14,500	275	14,775	43,000	54
230	4	300	11,730	600	12,330	40,000	54
350	6	300	15,500	600	16,100	61,000	45
450	6	277	23,500	600	24,100	74,000	54
480	6	277	24,500	600	25,100	76,000	52

Note No. 1—Above engines are complete with one flywheel, but no water circulating pump and no air compressor on engine. Equipment "B" includes auxiliary gasoline starting engine and air compressor combined.

INDUSTRIAL TYPE ENGINES

80	4	650	$3,200	$240	$3,440	7,200	$43
120	6	650	4,800	240	5,040	9,600	42
150	6	500	7,200	240	7,440	16,800	50
200	6	500	7,500	240	7,740	17,000	39

Note No. 2—The industrial-type engine is equipped with in-built air compressor and with centrifugal water circulating pump.

DIESEL PLANT[1]
KSTP Broadcasting Station, St. Paul, Minn.

Plant
1 cyl., 210 hp., 167 kva., 300 r. p. m.
Plant cost complete—$24,000.

Operating Data
First Diesel-operated broadcasting station.
Operation basis—
Average 85 kw. load per day.
589,475 kw.-hr. per year.

Costs		
Fuel	$2,947	
Lubrication	364	
Maintenance	210	
Miscellaneous and Supplies	150	
	$3,671	
Insurance and Taxes	456	= 1.86%
Labor	None	
Operating costs		$4,127
Fixed charges, 12% on $24,000		2,880
Total		$7,007

$\frac{\$7,007.00}{589,475}$ = 11.9 mills, with no labor costs.

[1]Courtesy *Power*, Feb., 1932.

DIESEL COSTS[1]
500 Kw. Diesel Plant

750-hp. modern Diesel	
Lubricating system, fuel tank, heater, muffler, tools, anchor bolts, freight and erecting engineer service	$40,000
500-kw. generator, exciter, with engine connections	4,500
Switchboard, voltage regulator, cables, etc	1,300
Piping	600
Fuel storage (30,000 gallons)	850
Labor to assemble	800
Cooling tower, basin pumps	950
	$49,000
Building (brick), chain hoist, machinery foundation, etc	4,500
Engineering on plans	4,000
Grand Total	$57,500

$\frac{\$57,500}{500 \text{ kw.}}$ = $115 per kw.

[1]Courtesy *Electrical World*, Nov. 14, 1931.

Natural Gas Engines

The territory in southern California, south of the Tehachapi, west of the Sierra Madre, and extending southward to San Diego, contains about 500,000 hp. in natural gas engines.

DIESEL PLANT[1]

Brown Shoe Company

Plant	Cyl.	Hp.	Kw.	Date
1. Brookfield	4	250	206	1924
2. Litchfield	3	200	100	1929
3. Dixon	2	80	50	1925
4o. Moberly	2	75	75	1925
4a. Moberly	4	125	175	1927
5. Salem	3	100	100	1927

Operating Costs and Fixed Charges (estimated)

Plant	Gal. Fuel	Fuel Cost	Lube Cost	Repairs	Kw.-hr. Costs	Kw.-hr. Per Gal.	Kw.-hr.
1. Brookfield	34,659	$1,486	$274	$17.27	.0067	7.52	261,000
2. Litchfield	16,730	765	221	26.21	.0074	7.89	132,000
3. Dixon	14,119	733	183	3.00	.0095	6.82	96,000
4o. Moberly	60,882	2,710	361	270.38	.0061	8.18	497,000
4a. Moberly	60,882	2,710	361	270.38	.0061	8.18	497,000
5. Salem	30,820	1,454	171	.....	.0067	7.86	242,000

Fixed charges—12% on $100 per kw.

	Fixed	Operating	Total
1.	9.57	6.7	16.27 mills
2.	9.10	7.4	16.5 mills
3.	6.25	9.5	15.75 mills
4o.	6.05	6.1	12.15 mills
4a.	6.05	6.1	12.15 mills
5.	4.95	6.7	11.65 mills

No labor included.

[1]Courtesy *Industrial Power*, Dec., 1931.

DIESEL PLANT DATA[1]

Plant	Service	Ann. Net Kw.-hr. Output	Plant L.F. %	Hp. Units	Cycles	Cylinders	Fuel Injection	Fuel Baumé Gravity	Fuel B. t. u. Gal.	Oil Consumption Fuel	Oil Consumption Lube
Hotel Chelsea, New York	Power	450,000	41	3–75	2	4	Solid	33	140,000	10.66	585
Freeport City, New York	Mun. L. & P.	7,958,000	31	1–360	4	4	Air	28–32	138,750	11.6	3,369
				2–750	2	4					
				2–1,150	2	6					
				1–1,500	2	8					
Opelousas, Louisiana	Mun. L. & P.	2,840,000	93	2–250	4	4	Air	28–30	114,000	12.5	2,400
				1–600	4	4					
				1–960	2	6					
Logan, Utah	Aux. Plant	1,403,280	..	1–675	...	4	Air	24	.....	11.6	202
				1–1,125	...	8					
Harlan, Iowa	Mun. L. & P.	1,710,500	23	1–375	4	3	Air	34	142,000	11.02	1,850
				1–500	4	4					
				1–625	4	5					
McMinnville, Oregon	Mun. L. & P.	3,400,000	29	1–1,500	2	8	Air	28–32	142,000	10.4	1,300
				1–600	4	6	Solid				
				2–300	2	6	Solid				
West Point, Nebraska	Mun. L. & P.	1,000,000	12.4	2–150	2	3	Air	26–30	.....	9.	850
				1–400	4	4					
				1–680	4	6					

Most kilowatt-hours generated on basis 10.5 to 11.6 kw.-hr. per gallon of fuel oil.
Fuel oil consumption shows wide range.
Most of above plants use some method of air cleaning, and some employ water treatment.
The Hotel Chelsea is a complete automatic plant.

[1]Courtesy *Power Plant Engineering*, Dec. 15, 1931.

DIESEL ENGINE POWER COSTS[1]

Operating Data and Costs of Diesel Power Plant of Vulcan Rail & Construction Co.

Operating Data	March 2 to Dec. 31, 1928 Aver. per mo.	1929 Jan.	Feb.	March	April	May	June	July	Averages Jan. 1 to July 31, 1929 Average per mo.	Average per kw.-hr.
Current generated, kw.-hr.	12,009	14,910	10,570	15,740	12,640	11,880	11,480	12,110	12,761	
Hours run	215	222¼	180½	227¼	213	222½	208¾	222½	213.7	
Average load, kw.	55.8	67.1	58.5	69.3	59.3	53.4	55.0	54.5	59.8	
Ratio average load / rated load per cent	34.9	42.0	36.6	43.3	37.1	33.4	34.4	34.0	37.4	
Fuel oil consumed, gal.	1,430	1,592	1,198	1,575	1,372	1,288	1,234	1,192	1,350	
Fuel efficiency, kw.-hr. per gal.	8.4	9.36	8.81	10.00	9.20	9.23	9.30	10.2	9.46	
Lubricating oil added, gal.	16	15¾	12½	17¼	16¼	17	14.75	16.75	15.7	
Lubrication efficiency, rated hp.-hr. per gal.	3,220	3,380	3,470	3,160	3,150	3,140	3,400	3,190	3,260	
Operating Cost:										
Fuel oil (6.05 cents per gal.)	$86.50	$96.30	$72.50	$95.20	$83.00	$71.90	$74.60	$72.10	$80.80	.63 cents
Lubricating oil	11.00	10.62	8.44	11.65	8.94	9.35	8.11	9.21	9.47	.07
Attendance	33.30	33.30	26.90	34.60	32.00	33.00	32.00	33.20	32.14	.25
Cooling water	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.01
Maintenance reserve	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	.24
Operating cost, dollars per mo.	$161.80	$171.22	$138.84	$172.45	$154.94	$145.25	$145.71	$145.51	$153.41	
Operating cost, cents per kw.-hr.	1.34	1.15	1.31	1.09	1.23	1.22	1.27	1.20		1.20 cents

Edgar J. Kates, Consulting Engineer.

[1]Courtesy *Power Plant Engineering*.

Details of Construction Costs, Diesel Engine Plant

BOARD OF PUBLIC WORKS, GRAND HAVEN, MICHIGAN

Hamilton & Weeber, Engineers, Grand Rapids, Mich.

	Material	Labor	Total
1. Building:			
Brick, concrete and steel construction, face-brick exterior with stone trim, 4,271.7 sq.ft Floor area 171,936 cu.ft. Contents including basement:			
Excavation	.....	$1,053.06	$1,053.06
Reinforcing steel	$1,015.49	.....	1,015.49
Concrete:			
Cement	1,575.24	.....	1,575.24
Gravel	573.91	.....	573.91
Form lumber	442.71	.....	442.71
Labor	.....	1,938.87	1,938.87
Huxman contract	4,272.48	.....	4,272.48
Equipment rental	67.71	.....	67.71
Miscellaneous	758.08	.....	758.08
Huxman contract—building above main floor line	23,121.40	.....	23,121.40
Plumbing	809.51	.....	809.51
Lighting system	1,562.99	557.93	2,120.92
Painting	356.54	.....	356.54
	$34,556.06	$3,549.86	$38,105.92
Building cost per sq.ft. $8.925			
Building cost per cu.ft. 0.2216			
(1,600 kw.) bldg. cost k.w. plant capacity—present .. 23.81			
(2,600 kw.) bldg. cost per k.w. plant capacity—future 14.65			
2. Diesel Engine Units and Foundations:			
Two—1140 b.h.p., 6-cylinder, 200-r.p.m. model VB, 4-cycle solid-injection, DeLaVergne engines with auxiliary compressed-air starting equipment, and two—800-kw. Elliott generators with two 17-kw. direct-connected exciters:			
Equipment contract	$101,979.00	.....	$101,979.00
Erection	1,520.02	$5,076.28	6,596.30
Foundations:			
Cement	1,131.21	.....	1,131.21
Gravel	897.66	.....	897.66
Form lumber	270.17	.....	270.17
Labor	.....	1,441.39	1,441.39
Equipment rental	280.51	.....	280.51
Pyrometers	547.96	.....	547.96
Insurance	350.00	.....	350.00
	$106,976.53	$6,517.67	$113,494.20
3. Switchboard and Station Power:			
Westinghouse contract	$10,123.96	$490.55	$10,614.51
Wiring to generators and exciters	1,601.52	324.63	1,926.15
Station auxiliary power lines	2,238.24	348.11	2,586.35
Brown Boveri voltage regulator	1,285.00	.....	1,285.00
	$15,248.72	$1,163.29	$16,412.01
4. Traveling crane:			
5-ton, 55-ft. span hand-operated Chisholm-Moore Co. (Crane erection incl. in Huxman building contract).	$1,681.38	.....	$1,681.38
5. Fuel Oil System:			
Graver tank works, 100,000 gal. steel storage tank, contract	$1,795.00	.....	$1,795.00
Excavation	.....	$2,059.60	2,059.60
Foundation and sidewalks	594.95	1,245.25	1,840.20
Piping	973.56	900.10	1,873.66
D-50 Hydroil purifier—contract	1,875.00	.....	1,875.00
50-g.p.m. fuel unloading pump	225.00	.....	225.00
King-Seeley tank gages	307.72	.....	307.72
	$5,771.23	$4,204.95	$9,976.18

	Material	Labor	Total
6. Lubricating Oil System:			
D-50 Hydroil purifier—contract	$1,875.00	.....	$1,875.00
Piping	254.92	$392.33	647.25
King-Seeley tank gages	135.72	.....	135.72
Two Griscom-Russell oil coolers	1,076.00	.....	1,076.00
	$3,341.64	$392.33	$3,733.97
7. Air Intake:			
Two Reed S.C.F. 6-unit air filters	612.50	.....	612.50
Piping	1,374.10	$197.45	1,571.55
	$1,986.60	$197.45	$2,184.05
8. Exhaust System:			
Two DeLaVergne 5-compartment mufflers	$835.00	.....	$835.00
Exhaust piping	1,221.62	$212.05	1,433.67
	$2,056.62	$212.05	$2,268.67
9. Cooling Water System:			
Intake and wells	$1,178.69	$1,654.21	$2,832.90
Equipment rental	138.38	.....	138.38
Elevated, 15,000 gal., steel storage tank on 50-ft. tower—contract	2,975.20	.....	2,975.20
Tank foundation	214.21	109.61	323.82
King-Seeley tank gage	139.65	.....	139.65
Pumps, one 400- and one 600-g.p.m. —contract	1,395.00	339.98	1,734.98
Piping and misc. material	1,074.53	.....	1,074.53
	$7,115.66	$2,103.80	$9,219.46
10. Building Heating Equipment:			
One American Blower Co. 3-30-F-4—916,000 b.t.u. unit heater	$523.43	.....	$523.43
Piping and office radiation	84.39	$193.30	277.69
	$607.82	$193.30	$801.12
11. Sub-station:			
One Delta-Star substation tower with bus and switching equipment	$2,056.54	.....	$2,056.54
Foundations	117.01	$193.29	310.30
Conductors and erection	1,572.27	957.22	2,529.49
Transformers, 2,000-k.va., 2,300-volt auto and one 833-k.va. 2,300/6,600-volt power	3,966.35	.....	3,966.35
	$7,742.17	$1,150.51	$8,892.68
12. Engineering:			
Hamilton & Weeber, design and consulting engineers	.....	$8,827.87	$8,827.87
Local inspections	.....	3.20	3.20
		$8,831.07	$8,831.07

SUMMARY

1. Building	$34,556.06	$3,549.86	$38,105.92
2. Diesel engine units and foundations	106,976.53	6,517.67	113,494.20
3. Switchboard and station power	15,248.72	1,163.29	16,412.01
4. Traveling crane	1,681.38	.....	1,681.38
5. Fuel oil system	5,771.23	4,204.95	9,976.18
6. Lubricating oil system	3,341.64	392.33	3,733.97
7. Air intake	1,986.60	197.45	2,184.05
8. Exhaust system	2,056.62	212.05	2,268.67
9. Cooling water system	7,115.66	2,103.80	9,219.46
10. Building heating equipment	607.82	193.30	801.12
11. Substation	7,742.17	1,150.51	8,892.68
Subtotal	$187,084.43	$19,685.21	$206,779.64
12. Engineering	.....	.....	8,831.07
Total construction cost	.....	.....	$215,610.71

Courtesy *Power*, Sept. 22, 1931

DIESEL GENERATING PLANT COST

8—1,500 B.hp. Diesel engines, f.o.b. S. D.	$351,000	
5—1,000 Kva., 11,000-volt, 3-phase, 60-cycle generators, f.o.b. S. D., with exciters 15-kw., 125-volt, each	47,000	
Switchboard, meters, etc.	10,000	
Foundations	15,000	
Buildings, 60x100x30 ft.	20,000	
Installation labor	10,000	
Crane	3,000	
Lub. oil centrifuge, heater and piping	3,000	
Fuel oil piping and pumps	2,000	
Fuel oil storage tanks, 50,000 gal.	4,500	
Water circulating pumps and piping	4,500	
Auxiliary air compressor	2,500	
Exhaust mufflers and piping	7,500	
Engineering and contingencies	24,000	$504,000

$$\frac{\$504,000}{5,000 \text{ kva.}} = \$101 \text{ per kva.}$$

LAKEVIEW, OREGON—DIESEL GENERATING PLANT

Utility System:

Unit No. 1 240-hp. engine.
170-kw. generator.
No. 2 240-hp. engine.
200-kw. generator.
No. 3 360-hp. engine.
300 kw. generator.

Because of 5,200 ft. elevation, these units operate at a maximum of 75 per cent of rating.

Operating Data:
October, 1930 to October, 1931 (12 months)

Plant Output	643,064 kw.-hr.
Operating Costs:	
Fuel Oil	@ $2.39 per bbl.
Lubricating Oil	.56 per gal.
Operating Costs	2.12¢ per kw.-hr.
Fixed Charges	4.31¢ per kw.-hr.
Total Cost	6.43¢ per kw.-hr.

Energy used by auxiliaries = 6% of output.

MODERN DIESEL EQUIPMENT REDUCES POWER COST AT WINTERSET, IOWA[1]

Studies of the city's requirements showed that a unit of about 500-kw. capacity would be desirable. However, as plants of this type experienced rapid growth, it was decided also to consider a unit of 750-kw. capacity.

The following four plans were considered:

(1) Steam turbine, condensing, no superheat.
(2) Steam turbine, condensing, with superheat.
(3) Steam turbine, non-condensing, without superheat.
(4) Oil engine unit.

COMPARISON OF ESTIMATED COSTS

	Plan 1		Plan 2		Plan 3		Plan 4	
Capacity, kw.	500	750	500	750	500	750	500	750
Installation cost	$61,860	$70,600	$63,435	$72,176	$48,262	$53,197	$65,604	$90,431
Installation cost per kw	123.72	94.13	126.87	96.23	96.52	70.93	131.21	120.58
Production cost, yearly	21,070	21,070	20,038	20,038	28,848	28,848	13,410	13,410
Production cost per kw.-hr.	2.1c	2.1c	2.0c	2.0c	2.88c	2.88c	1.34c	1.34c
Total operation	$27,870	$27,870	$26,838	$26,838	$35,648	$35,648	$20,210	$20,210
Operation cost per kw.-hr.	2.79c	2.79c	2.68c	2.58c	3.56c	3.56c	2.02c	2.02c
Total annual cost, including interest and depreciation*	$40,374	$41,227	$39,496	$40,349	$46,926	$47,419	$34,410	$35,985
Total cost per kw.-hr.	4.03c	4.12c	3.95c	4.03c	4.69c	4.74c	3.44c	3.60c

*The fixed charges include interest on a small issue of outstanding bonds and depreciation on the entire system.

BEST BIDS ON EQUIPMENT

Steam Plant		
Capacity, kw.	500	750
Turbine	$18,400	$22,743
Condensers	6,345	8,095
Boiler	10,807	10,807
Brickwork	4,045	4,045
Stokers	6,618	6,618
Other items	17,710	20,250
Total	$63,925	$72,558
Cost per kw.	$127.95	$96.74

Diesel Plant			
Capacity, kw.	500	750	500*
Engine	$43,625	$60,573	$37,790
Other items	8,770	10,125	8,770
Total	$52,395	$70,698	$46,560
Cost per kw.	$104.79	$94.26	$93.12

*Equipped with supercharger.

OPERATING COST

	Steam Operation, 1929			Steam and Diesel Operation, 1930		
	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.
Kw.-hr. generated	80,910	78,880	87,150	94,660	91,750	105,200
Coal, tons	251	249	292	83	58	38
Fuel oil, gal.	.....	.....	.....	9,454	10,250	11,668
Fuel cost	$1,295	$1,285	$1,507	$815	$743	$723
Labor cost	450	450	450	350	350	350
Lubrication cost	.....	.....	.....	20	20	20
Production cost	$1,745	$1,735	$1,957	$1,185	$1,113	$1,093
Production cost per kw.-hr., cents	2.16	2.20	2.24	1.25	1.21	1.04
Fixed charges per kw.-hr. (new equipment), cents	.....	.....	.....	0.54	0.49	0.38
Total cost per kw.-hr., cents (Prorated supplies and repairs omitted)	.....	.....	.....	1.69	1.70	1.42

[1]Courtesy *Power*, July 7, 1931.

LA CROSSE, KANSAS—DIESEL GENERATING PLANT[1]

Municipal Power Plant
Unit No. 1 120-hp. engine—1922
No. 2 60-hp. engine—1926
No. 3 330-hp. engine } Since 1926
No. 4 260-hp. engine }

Ten Year Operating Record

Year	Fuel Cost	Lube Cost	Repairs Supplies	Labor Cost	Total Cost	Kw.-Hr. Generated
1921	$2,280.18	$151.91	$179.20	$3,129.60	$5,740.89	381,548
1922	2,199.90	189.00	465.34	3,780.00	6,634.24	407,568
1923	2,215.68	136.54	636.59	3,780.00	6,768.81	457,887
1924	2,264.07	198.40	120.73	3,780.00	6,363.20	515,453
1925	2,565.43	275.42	166.59	4,170.00	7,177.44	536,106
1926	3,663.75	290.06	150.62	3,630.00	7,734.43	589,890
1927	3,043.15	334.53	315.87	3,656.00	7,351.55	583,141
1928	3,076.89	322.23	174.44	3,600.00	7,173.56	629,936
1929	3,378.94	744.34	216.47	3,780.00	8,119.75	791,568
1930	2,302.21	806.96	53.40	3,750.00	7,002.57	864,926
	$27,082.20	$3,449.39	$2,479.25	$37,055.60	$70,066.44	5,758,023

Summary of Results

Kw.-hr. per gal. fuel (10 years) 9.67
Kw.-hr per gal. fuel (1930) 10.25
Total operating cost kw.-hr. (10 years) ..... 1.21¢
Total operating cost kw.-hr (1930) ..... 0.81¢
Average fuel oil cost ..... 4.55¢ gal.
Average lubricating oil cost ..... 52.6¢ gal.

[1]Courtesy *Power*, July 2, 1931.

DIESEL PLANT[1]

Harlan Municipal Utilities, Harlan, Iowa.

Plant
Plant contains 3 generating units.

1	3 cyl.	375 hp.	250 kw.	225 r.p.m.
2	4 cyl.	500 hp.	340 kw.	225 r.p.m.
3	5 cyl.	625 hp.	430 kw.	225 r.p.m.
			1,020 kw. total	

All engines are 4-cycle, air-injection.

1930 Operating Data
1,710,500 kw.-hr. generated.

155,197 gal. fuel	$7,201.10
924.5 gal. lube	462.25
666 lb. rags	108.84
782,940 gal. water	201.50
Miscellaneous	182.50
Labor	7,116.00
	$15,272.19

Operating Cost
8.92 mills per kw.-hr.
11.02 kw.-hr. per gallon of fuel oil.
1,850 kw.-hr. per gallon of lube oil.
1,020 kw. @ $100.00 = $102,000 @ 12% = $12,250.
Fixed charges—7.17 mills.

Total Cost—Kw.-hr.

Operating Costs	8.92 mills
Fixed Charges	7.17 mills
Total	16.09 mills

[1]Courtesy *Power Plant Engineering*, Mar. 1, 1932.

SPECIAL EXTRACTIONS FROM 1931 A. S. M. E. REPORT

Part I:							
Plant No.	82	52	73	45	130	7	41
No. engines	6	4	4	5	4	5	3
Year put in	.....	1915–30	1923–27	1922–26	1923–30	.....	1912–28
Kw. capacity	3,964	3,110	3,400	2,900	2,524	1,795	1,800
Investment:							
Land	$15,210	$10,584	.....	$25,000	$2,787	$ 3,000	$ 5,785
Buildings	.....	171,098	.....	46,396	27,051	10,434	50,309
Equipment	.....	460,183	$345,000	458,227	240,398	155,655	214,359
Total cost	941,172	641,865	.....	529,623	270,236	173,024	273,474
Cost per kw.	237	206	101	183	107	96	152
Operating Data:							
Time hours	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Kw.-hr., gen	8,107,305	7,391,500	8,473,300	7,492,325	4,760,800	3,526,330	4,118,290
Per cent kw.-hr. plant	1.8	1.8	5.4	7.8	5.8	8.9	1.2
Annual load factor	31.3	33.5	37.9	34.9	41.8	38.0	39.2
Fuel oil cost, gal.	5.71	5.7	1.30	5.29	4.72	4.79	5.19
Lube oil cost, gal.	76.5	71.1	58.80	48.0	56.70	51.1	58.6
Switchboard Cost—Kw.-Hr. (Mills):							
Fuel	5.22	5.30	1.34	5.18	4.59	4.52	5.09
Lube	0.52	0.38	0.31	0.09	0.89	0.35	0.48
Attendance	3.73	2.83	2.62	1.77	1.36	3.17	4.08
Supplies	1.38	0.74	0.01	0.04	0.77	1.19	0.37
Engine repairs	1.91	0.56	0.10	1.01	0.82	1.57	0.63
Other repairs	1.08	0.48	0.01	0.10	0.17	0.31	0.15
Total operating cost	13.86	10.29	4.39	8.20	8.60	11.11	10.8
Fixed charges 15% ($100.00 per kw.)	17.45	13.00	6.10	10.60	8.50	7.37	10.0
Total cost kw.-hr.	31.31	23.29	10.49	18.80	17.10	18.48	20.8

SPECIAL EXTRACTIONS FROM 1931 A. S. M. E. REPORT

Part II:							
Plant No.	176	13	527	247	265	1056	109
No. engines	3	3	2	3	2	1	2
Year put in	1926–28	1900–25	1929	.....	1927	1929	1927–29
Kw. capacity	1,230	800	480	275	110	565	1,200
Investment:							
Land	$ 174	$ 2,000	$ 3,500	$ 10	$ 500	$ 1,623	$ 257
Buildings	17,029	14,000	5,920	7,000	3,416	32,597	17,705
Equipment	174,802	121,500	63,000	36,000	27,000	112,556	119,776
Total cost	192,005	137,500	72,420	43,510	31,254	146,776	137,728
Cost per kw.	156	172	151	158	284	260	115
Operating Data:							
Time hours	35,040	8,760	7,344	8,760	8,760	.....	2,295
Kw.-hr., gen.	18,773,800	1,291,100	733,300	429,890	184,000	.....	893,690
Per cent kw.-hr., plant	0.9	12.4	8.2	0.4	.....	.....	0.9
Annual load factor	.....	32.7	.....	28.9	.....	.....	.....
Fuel oil cost	7.70	5.69	3.87	6.0	9.14	.....	5.53
Lube oil cost	75.70	39.7	65.0	55.0	59.9	.....	75.7
Switchboard Cost—Kw.-Hr. (Mills):							
Fuel	7.58	6.60	5.02	8.12	13.48	.....	6.33
Lube	1.38	0.65	1.59	1.10	1.76	.....	1.26
Attendance	2.81	4.88	3.97	10.79	13.58	.....	3.78
Supplies	0.79	0.54	0.25	0.11	1.10	.....	0.88
Engine repairs	0.57	0.39	0.04	.....	0.71	.....	0.60
Other repairs	.....	0.08	0.04	.....	.....	.....	0.11
Total operating cost	13.13	13.14	10.91	20.12	30.63	.....	12.96
Fixed charges 15% ($100.00 per kw.)	6.15	15.95	14.80	15.20	25.40	.....	4.00
Total cost kw.-hr.	19.28	29.09	25.71	35.32	56.03	.....	16.96

DUNCAN, OKLA., MUNICIPAL LIGHT PLANT REPORTS POWER COSTS[1]

The Duncan, Okla., municipal light plant in the year ending July 1, 1930, showed a net profit of $22,984.79 after deduction of all operating and fund expenses. The various terms of cost are shown in the tabulation.

	Total	Per Kw.-Hr.
Power Plant		
Salaries and labor	$ 9,323.60	.00387c.
Maintenance of power plant equipment	2,684.44	.00111c.
Fuel and lubricating oil	9,328.46	.00388c.
Insurance	575.00	.000239c.
Water, for cooling, 2,281,500 gal.	798.52	.000332c.
Miscellaneous expense	894.44	.000372c.
Total maintenance and operation	$23,604.46	.009803c.
Distribution System		
Maintenance of lines and equipment	$ 1,560.70	.000694c.
Salaries and labor	4,069.20	.00169c.
Total maintenance and operation	$ 5,629.90	.00234c.
General and Office Expense		
City clerk's dept. one-third total expense	$ 2,284.00	.00095c.
Mayor and comr's dept. one-third total	1,960.00	.00081c.
Office rent	400.00	.000166c.
Total general expense	$ 4,644.00	.00193c.
Capital Expense		
Annual maturity of interest, 6 per cent	$18,207.30	.00757c.
Sinking fund, 5 per cent	15,172.75	.00631c.
Total capital expense	$33,380.05	.01388c.
Total expense	67,258.41	.02701c.
Total gross revenue	$90,243.20	
Less expense	67,258.41	
Total net profit	$22,984.79	

[1]Courtesy *Power*, Nov. 4, 1930.

Records show that approximately 100,000 hp. are used in the agricultural and industrial fields, the balance being used by the oil companies in the oil fields and refineries. The major hp. used under the agricultural classification is found in pumping service, particularly by the small mutual water companies.

The sale of engines has been carried on by a cooperative plan, involving the engine manufacturers and the gas utility companies distributing gas in that ter-

McMINNVILLE, OREGON—DIESEL GENERATING PLANT

Population 3,500

Municipal System:
Two 300-hp. semi-Diesels
Two 250-kva. alternators
85 per cent power factor
} Cost = $61,000 in 1924.

Cost installed ..... $143.50 per kw.

1930 installed, one 1,500-kw. generating unit.

ELECTRIC RATES

Commercial Lighting Rates:		
First 50 kw.-hr. @	8¢	kw.-hr.
Next 50 kw.-hr. @	6¢	kw.-hr.
Next 200 kw.-hr. @	4¢	kw.-hr.
Next 500 kw.-hr. @	3¢	kw.-hr.
Balance @	2.5¢	kw.-hr.
Domestic Lighting Rates:		
First 30 kw.-hr. @	8¢	kw.-hr.
Balance @	2.5¢	kw.-hr.
Power Rates:		
First 500 kw.-hr. @	5¢	kw.-hr.
Next 500 kw.-hr. @	3¢	kw.-hr.
Next 5,000 kw.-hr. @	2¢	kw.-hr.
Next 5,000 kw.-hr. @	1.5¢	kw.-hr.
Balance @	1¢	kw.-hr.

Any Diesel plant could be successful with these resale rates.

MUNICIPAL LIGHT PLANT, BALDWIN CITY, KANSAS[1]

1917—One 165-hp. 4-stroke Diesel.
1924—One 180-hp. 4-stroke Diesel.

Baldwin City furnishes power to a utility at 4 cents per kw.-hr. at switchboard.

Resale Rates:
Lights—Flat rate 9 cents per kw.-hr.
Power—First 250 kw.-hr. @ 4c.
Next 750 kw.-hr. @ 3c.
Over 1,000 kw.-hr. @ 1½c.

OPERATING COSTS

	1929	1930
Total kw.-hr. generated	527,145	539,500
Load factor (per cent)	26.1	26.7
Unit cost of oil per kw.-hr.	0.48	0.36
Kw.-hr. per gal.	9.35	9.60
Fuel used, gals.	56,230	59,557
Plant Operating Costs:		
Fuel	$2,541.32	$2,482.01
Lubricating Oil	677.80	882.61
Repairs	56.35	2,733.11
Attendance	5,710.00	5,120.00
Switchboard Costs	$8,958.47	$10,217.73
Fixed Charges	6,209.30	6,147.30
Total Cost Kw.-hr.	$0.0289	$0.0303

[1]Courtesy *Power*, April 13, 1931.

ALTURAS, CALIFORNIA—DIESEL GENERATING PLANT

Utility System
Unit No. 1—295-hp. engine.
200-kw. generator.
No. 2 655-hp. engine.
470-kw. generator.
Because of 4,400 ft. elevation, these units operate at a maximum of 80 per cent of their rating.

Operating Data
January to September, 1931, inclusive.
Plant output ..... 338,072 kw.-hr.

Operating Costs

Fuel Oil	@ $2.22 per bbl.
Lubricating Oil	42.5¢ per gal.
Operating Costs	2.39¢ kw.-hr.
Fixed Charges	4.11¢ kw.-hr.
Total Cost	6.50¢ kw.-hr.

Energy used by auxiliaries = 7.3% of output.

ritory. This cooperative plan involves manufacturers and utility salesmen working together on plant layout and, after the sale has been made, we quite frequently find that the gas company carries the deferred payment contract and collects the money both for the payment of the engine and the monthly gas sales. We also find that it is necessary for the gas distributing company to stock repair parts and maintain a staff of repair men who are available on call from the various farmers. This set-up is necessary to keep the engines in proper condition and to assure continuity of service.

At the present time the use of electric motors in this gas field is increasing at a greater rate than the use of gas engine equipment and there are numerous cases where unsuccessful gas engines have been replaced with central station power.

Engine Costs

The past sales efforts of engine manufacturers have been retarded by the high first cost of engines. This high first cost at the present time is due to the heavy, slow-speed, horizontal-type of engine construction used by companies selling engines in that territory.

There are very few engines found in this territory that are direct connected to pumping or other mechanical equipment. We therefore find it necessary to purchase engines, mufflers, air-starting unit, cooling equipment, necessary belting and pulleys, idlers, and gas-supply piping. It is also necessary to install this equipment on a good foundation, generally on concrete in this territory.

Engine Prices

Common prices quoted in this southern California area are given below:

Single-Cylinder—25-30-40 hp. @ $40 per hp.
50-60-80 hp. @ $32 per hp.

Two-Cylinder—120 hp.)
160 hp.) $30 to $35 per hp.
200 hp.)

Four-Cylinder—240 hp)
320 hp.) $30 to $35 per hp.
400 hp.)

The above prices are for bare engine and we must add muffler costs, air starting unit costs, and installation costs.

Muffler Costs— 30 to 120 hp.—$100 to $150.
120 to 400 hp.—$150 to $250.

Air-starting Units (air tank included)—
Belted Units—$125.
Separate Engine Units—$200 to $300.

Installation costs depend on many variables and location. We may consider complete installation costs between $3 and $6 per hp.

In considering the installation cost, it is necessary to consider additional auxiliary equipment such as: belts, idler pulleys, water cooling equipment, building for housing installation. Past operating experience shows that it pays to install jobs on proper foundations.

The chief causes for engine replacements during the past years, where electric motors have been installed, are operating difficulties. It is due to lack of skilled attendance and improper repair work.

In many cases, in comparing an engine installation with direct-connected motors, the salesmen have neglected to compute the losses due to belting and idlers. These losses may run to ten per cent of engine output.

*Oil Industry Electrification**

The oil industry electrification committee proposed to concentrate its efforts for the year on the following:

1. To obtain a complete oil industry power survey for the purpose of ascertaining the amount of electric power used in the industry, also to find out the amount of potential power still available.

2. To continue to collect oil industry operation data, hoping to obtain sufficient material to enable the committee to edit a handbook.

3. To obtain data on tests that have been completed by Westinghouse Electric & Manufacturing Company in conjunction with the Standard Oil Company on electrically driven mud pumps which develop performance characteristics similar to the steam pumps.

AT THE Los Angeles meeting of the oil industry electrification committee, report was made on the completed oil industry power survey, results of which have been tabulated and summarized.

SUMMARY OF OIL INDUSTRY POWER SURVEY SHOWING HORSEPOWER OF CONNECTED LOAD IN ALL BRANCHES OF THE OIL INDUSTRY IN TERRITORY SERVED BY THE SOUTHERN CALIFORNIA EDISON CO. LTD., JUNE 1, 1931

	Motors		Steam Eng.		Gas Engines		Diesel Eng.		Per Cent
	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.	Electric
Pumping wells...	1,419	51,170	769	26,195	2,342	84,601	.	...	31.6
Drilling wells....	98	8,086	1,021	110,006	6	3,120	.	...	6.7
Gasoline plants..	265	8,621	848	18,806	716	101,886	.	...	6.6
Refineries.....	1,389	42,234	245	29,003	35	3,705	1	100	56.3
Pipe line pumps.	711	40,569	1,020	43,981	80	17,898	4	700	39.2
Miscellaneous...	1,065	25,017	1,820	50,554	233	35,245	.	...	22.6
Gas lift.....	156	9,830	108	9,055	37	2,175	.	...	46.7
Electric 482 dehydrators.	.....	3,663	....	.....	....	.....	.	...	....
Totals.....	5,103	189,190	5,831	287,600	3,458	248,630	5	800	26.00

No. boilers in territory—3,776. Hp. 318,506.
No. of wells in territory drilled with electric motors—273.
Total oil industry power load in So. Calif. Edison territory.....726,220 Hp.
Total oil industry motor load on So. Calif. Edison lines.....189,190 Hp.
Per cent of total oil industry load in So. Calif. Edison territory on So. Calif. Edison lines..... 26.

The committee has been unable to collect sufficient oil industry operating cost data to warrant the publishing of a handbook at this time. The material which the committee has on hand will be turned over to the next oil industry electrification committee.

The test data on electric-driven mud pumps were not available for our P.C.E.A. committee, but will be published by the oil industry electrification committee of the P.C.E.B.

During the year it was suggested that the name of our committee be changed from oil field electrification committee to oil industry electrification committee. The latter name was adopted.

Valuable oil-well pumping data were collected by the subcommittee on oil-well pumping. These data will be turned over to the next committee.

Cost data were obtained on mud-screen operation by members of the committee.

* Report of oil industry electrification committee, general power bureau, Commercial Section. C. C. Stewart, chairman. C. C. Bartlett, Louis Berger, P. J. Denninger, J. H. Fenton, A. W. Frost, H. C. Hill, T. J. Johnston, J. P. Kastl, A. R. Tanner, C. H. Thrane.

*Cooperation With Electrical Inspectors**

Satisfactory results are reported from the individual and committee contacts made with electrical inspectors of California during the year.

THE object of this committee has been to acquaint the inspectors, both individually and as an association, with the problems of the industry as viewed from the commercial and engineering standpoints and also to become acquainted ourselves with the problems of the inspectors with the idea of coordinating our efforts for the best interests of the public.

Many meetings have been held with the inspectors. Members of the committee have attended the annual convention of inspectors in San Francisco and have attended group meetings of their local associations, as well as making individual contacts.

We have met with the heartiest and most sympathetic cooperation on the part of the inspectors and many controversial problems have been ironed out satisfactorily. We recognize that the inspectors occupy a most important place in the electrical industry and should be acquainted with the problems of the other sections, so that they can be guided accordingly. We wish to report most satisfactory progress in this regard. We believe a foundation has been laid for the continuation of a most satisfactory arrangement, to the end that the public will be better served.

* Report of joint committee of the Commercial and Engineering Sections to contact electrical inspectors of California. H. C. Rice, chairman, R. R. Cowles, W. H. Frampton, A. E. Holloway, H. B. Webb.

Engineering Section[1]

ACCIDENT PREVENTION COMMITTEE REPORTS*

Accidents result not only in occasional loss of life and limb and consequent heavy financial loss to worker and company, but also in severe damages to equipment and interruption of service.

Proper supervision, one fundamental requisite of foremanship, will prevent these accidents and their economic losses and thus reduce the cost of service.

THE keynote of the accident prevention committee's entire program this past year has been supervision to prevent accidents.

In the selection of supervisors and workmen, ability to prevent accidents must be considered as one of the fundamental requirements. Selection for hazardous or otherwise important assignments must be on the basis of observation of the ability of the individual to complete assignments safely, as well as according to any other standards. The supervisor must learn that there are various methods for the prevention of accidents. He must know what these are and how to apply them and must remember that careful supervision is at all times required, in combination with any direct preventative method. He must realize that no method will free him from the obligation of supervision and, furthermore, that the extent of supervision in any case must completely and adequately offset any inadequacy in other methods.

For instance, his responsibilities require the closest supervision when he is employing transient workers (men he has not selected, trained and observed) on a hazardous job such as emergency repairs. For other than emergency work there is ample opportunity for the selection, training, discipline and observation of men, leading to definite knowledge of their capacities for the performance of work as it comes up.

In the planning of any job, the element of safety is as important as any other. The hazards must be fully appraised and various methods of protection considered. Each man selected must be known to have the capacity to perform his function safely. Otherwise the hazards of the job must be removed or reduced to the known capacity of the man, or the job put off until men of required capacities can be obtained, or other measures of protection made possible.

Selection of supervisors, foremen and workmen is made, not only at the time of initial employment with the company, but on the occasion of each assignment. This is particularly true in our industry, where practically every assignment is different in its character, location, requirements and circumstances.

It is because of these different conditions that no fixed rule, guard or device can be established. Therefore, the supervisor's responsibility is greater, for he must plan the job according to its conditions.

Tools and materials may be tested to determine their adequacy and capacity to meet requirements. Furthermore, these, in general, retain their properties at least for a reasonable period and, also, it is possible to establish definite methods of testing and to make measurements which can be recorded by instruments.

In dealing with workmen, however, the problem is more complex and the conditions less fixed. For instance, a man's characteristics may be changed overnight by something that transpires; his capacity, either physical or mental, may be greatly reduced.

The supervisor must, therefore, be to some extent what might be termed a psychologist. To prove that this is possible, it is only necessary to refer to some foremen who are psychologists to the extent that they actually do know their men intimately. They know their traits and faults and habits, even their thoughts and inclinations. Such a foreman knows his men's vices. He knows their home life. He knows their moods.

He is such a psychologist that every man in the gang respects him, loves him, will fight for him—right or wrong, will obey him without question; in fact, will follow him through fire.

He is the one to whom the men go for information, not only concerning their work, but pertaining to personal affairs. They know he will never divulge their secrets; but they also know that, if one should go wrong on the job, his mistake will not be covered up. They know he will fight for them and protect them, and he has taught them that, in order to protect them, no accident can be covered up.

It is agreed that the foregoing requirement calls for supermen as foremen.

As a matter of fact, days of keen competition are ahead and these will require supermen throughout the organization, from general manager to workman. Therefore, the man who concludes that these specifications can only be met by a superman, is well off if he acts accordingly, either fitting himself as one or stepping aside for one who will.

Accident Statistics

The National Electric Light Association, the American Gas Association and the National Safety Council are getting together to use one set of accident statistics. In the meantime, this committee is experimenting to find what comparative accident data may be reasonably obtained and used with sufficient effectiveness to justify their collection.

The first data have been assembled and their inconsistencies noted. The next step will be to endeavor to remove these inconsistencies. The work required, depending upon the company's setup, must be balanced against the possible benefits.

What Are the Benefits of First-Aid Training?

The student gains a knowledge of the seriousness of injuries and their complications and, therefore, indirectly learns to appreciate injury-prevention.

The results of injuries are greatly diminished through proper first aid to the patient. Proper knowledge and preparedness reduces demoralization of the crews. Severity rates are reduced, so that the cost of accidents, to both the company and the employee, is reduced.

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[1] Executive committee: H. H. Buell, chairman. R. M. Peabody, vice-chairman. K. B. Ayres, P. E. Chapman, A. W. Copley, R. R. Cowles, F. E. Dellinger, F. B. Doolittle, R. H. Halpenny, N. B. Hinson, A. G. Jones, S. J. Lisberger, H. H. Minor, E. R. Northmore, F. G. Philo, C. E. Schnell, E. R. Stauffacher, C. E. Young.

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* J. M. Buswell, San Joaquin Light & Power Corporation, chairman. H. B. Wells, Los Angeles Gas and Electric Corporation, vice-chairman.
California Railroad Commission: C. T. Mess.
Coast Counties Gas & Electric Company: J. Barrington.
Electrical World: W. C. Heston.
General Electric Company: J. M. Dodds.
Industrial Accident Commission: G. E. Kimball.
Los Angeles Gas and Electric Corporation: J. C. McClung.
Pacific Gas and Electric Company: F. W. Davis, S. C. Dickinson, Hector Keesling, E. G. McCann, S. G. Olson.
San Diego Consolidated Gas & Electric Company: W. E. Richmond, W. H. Talbot.
San Joaquin Light & Power Corporation: R. J. Tilson, J. M. Wainscoat.
Southern California Edison Company Ltd.: H. Miller.
The Southern Sierras Power Company: J. S. Allan.
Westinghouse Electric & Manufacturing Company: David Hall.

The employee practices and teaches first aid outside—at home, in the clubs, along the highway, at seaside and mountain. Thus his family and neighbor benefit. To the extent that his family benefits, he is a safer employee, having less worry; to the extent that the public benefits, we have rendered a service we may hope will be appreciated.

Our employees are rapidly adding to the list of their life-saving and valuable first-aid achievements, three-fourths of these being services rendered to the public, simply through the use of knowledge necessary to them in their own hazardous jobs.

During the year two Insull medals were awarded to two employees of the Southern California Edison Company Ltd. —to Donald H. Haremza and Addison Lester Lake. In addition, the National Safety Council president's medal was awarded in three cases—to Orin Dale and C. E. Myers of the San Joaquin Light and Power Corporation and to H. J. Davies of the Southern California Edison Company Ltd.; also several other certificates and company medals were awarded for distinguished life saving, resuscitation and first-aid services.

Hospitalization for Employees

Medical care and hospitalization for employees and their families at a cost within their means is recommended as an important subject for consideration by this committee next year and by the Pacific Coast Electrical Association and company executives.

Utilities are required to maintain some type of hospital and medical service. These are more complete with the larger units. The largest maintain hospitals and full-time medical staffs, etc. The smaller units have some sort of arrangement with the local private or public institutions.

Need of hospitalization, particularly for people of moderate means, is becoming more generally recognized: to reduce incidence and duration of illness, communication of disease, and pauperism; to encourage hospitalization of people who need it but "put it off", not having the price.

A worker is unsafe if his mind carries worry or anxiety over disease, illness or injury to himself or to a member of his family. Anything we do to reduce this, makes him a safer, a more loyal and otherwise a more efficient worker. From this standpoint alone, it will pay to go as far as possible, at least to make arrangements with local institutions and medical men so that our employees and their families can be thus cared for.

In addition to facilities afforded by the larger companies in the larger cities through their medical departments and through their mutual benefit associations, the following are noted:

Hospital associations (public); medical examinations, either free or for small fees, afforded by insurance companies to policy holders; employee group health, accident or hospital insurance; county or city hospitals for people of moderate means; Letterman and other Army and Navy hospitals for ex-soldiers, sailors or marines. These should be brought to the attention of our employees.

Recognition of Accident-Free Records

Ability to work safely or to direct work safely is acknowledged as a requisite which must be considered in the selection of men for employment, promotion and, particularly for special assignments. Records in this respect should, therefore, be established and maintained, based on responsibility for accidents. An injury to an employee and the disability resulting, the cost of its treatment and his compensation are, of course, recorded in the personnel records. These do not necessarily reflect against the injured employee's safety record, but rather against the records of the employees responsible for the accidents. Since foremen and supervisor are mainly responsible for safety, these records will be expected to reflect most against their records, although the records of the workmen should show the extent of their responsibility for any accidents.

The committee at each of the three meetings of this year agreed to the following:

As safety is only one of the required characteristics of successful workmanship or foremanship or supervision, no reward should be offered for success in this field, any more than for other characteristics. Reprimands and penalties in different forms, even to the extent of discharge from service, are imposed for failure. On the other hand, continued employment and promotion or selection for important work, perhaps paying higher wages or salaries, are the rewards for good service, including safety.

Certificates testifying that a man has worked or supervised work for one, two or any other number of years without having been responsible for an accident are recommended in principal. It is also agreed that these would be valuable as important testimony for use by an employing agent or supervisor.

The following points must be observed: The system must not develop a "black list." A certificate must not be issued to a man who has been responsible for an accident, but who has been fortunate enough to escape injury himself. A certificate must not be denied a man simply because he was injured in an accident, unless a degree of responsibility for it rested upon him.

Accident Investigations

Accident investigations should be conducted with a view to disclosing the fundamental cause and responsibility, so that the fault may be corrected in order to prevent future similar accidents.

The workmen and supervisors alike must be taught and convinced that only by the fullest and frankest investigation and report of such accidents as occur, can we be led to the conclusions that will enable us to set up rules and safe practices and safeguards, by which they and their fellows may be protected in the future.

They must realize that their own crew is not alone interested. While they may benefit by an experience, every other crew on the system, and, in fact, in the industry, should be put on guard and should have the benefit of the experience, and the company must be given the opportunity to establish proper safeguards for the protection of others.

Workmen and supervisors alike must be convinced that protection of themselves and each other does not result from "hushing" an accident or from lying about it, but that this actually has the opposite effect. It sentences them to continued exposure, generally far more serious, even deadly, than any exposure to penalties may be. "Hushing" may only temporarily protect an employee from the maximum penalty of discharge, which would require him to seek work elsewhere, perhaps a better man, but the penalty of that protection will be paid sooner or later by him or some other employee, and that penalty may be his death or loss to his family, not to mention the economic loss to the company.

Therefore, since workmen and supervisors alike are prone to conceal facts, even to the extent of lying, either to avoid the penalty or the breaking of a departmental record, or to protect a fellow employee, they must be taught better. The method of penalizing those responsible for accidents and for violation of safety rules or orders, etc., must be carefully established and controlled. The penalties must be judicially imposed and must be properly explained, not only to the men but to the organization. They must take into consideration not only the degree of his responsibility, but the extent to which he frankly and honestly acknowledged the circumstances and assisted in investigating methods of prevention It must be fair, too, in view of penalties imposed upon others, either in the same or in other cases.

Then the investigation must be so conducted, and by such a man or group, that the correct conclusions can be arrived at. In an important case, at least, a board of review or investigation should be formed. This should not include workmen, inasmuch as the responsibility of the supervisor may be involved. It should not include employees of the immediate department, unless it is large enough so that those appointed will be sufficiently removed that they represent disinterested parties. It should include one or more members of the public, if a member of the public is involved in the accident, at least in some cases; it should include some members picked from different lines of work entirely. It may not have the authority to assess the penalty, but it should have the authority to conclude the investigation. The fixing of the penalty is usually best accomplished by a group out of the immediate department, under the counsel of the board of review, perhaps, or at least of an executive or high officer.

The immediate foreman, as a rule, can himself furnish or can find out all of the facts, if he will, and is an important witness, and it is therefore important that he be instructed as to his responsibility, and convinced, in advance.

Report From the National Electric Light Association

The chairman attended the national committee meeting in October, and J. C. McClung attended the February meeting. In addition, G. H. Hagar reported to us on the February meeting.

Rope safeties are almost universally condemned.

Rubber gloves are improving and studies are continued so as to obtain data on the newer types of glove.

Reports on hot-line tools, cable identification, grounding practices, and holdoff procedure are all under way and some are ready for publication.

The accident prevention course for linemen is being revised and a bibliography of all reports and safety material is being prepared.

All of the foregoing represent major activities of the national committee, in most cases proceeding jointly with other appropriate national committees.

Some representatives of the national accident prevention committee attended each of the other section committees and gave a few minutes talk, presenting a curve showing the downward trend of accident rates in the industry since 1913.

Intercommittee Relations

A quite successful arrangement was made this year for the attendance at our committee meetings by representatives, usually the chairman or vice-chairman, of all other Engineering Section committees and of the other P.C.E.A. sections, such as transportation, material and supplies, publicity and public relations.

These representatives, definitely assigned to attendance throughout our meetings and frequently contributing to discussions, increased the value of the meetings.

Service to Foremen and Supervisors

At each of the three Engineering Section conclaves a mass meeting was arranged for foremen, supervisors and engineers. The proceedings of the committee were very briefly stated and the balance of the one-hour session was devoted to a talk on the foreman's and supervisor's responsibility for the prevention of accidents. The first of these mass meetings was addressed by Will J. French, director of the Industrial Accident Commission of California; the second was addressed by B. F. Pearson, manager of industrial relations, Southern California Edison Company, Ltd.; the chairman of this committee addressed the meeting at Fresno.

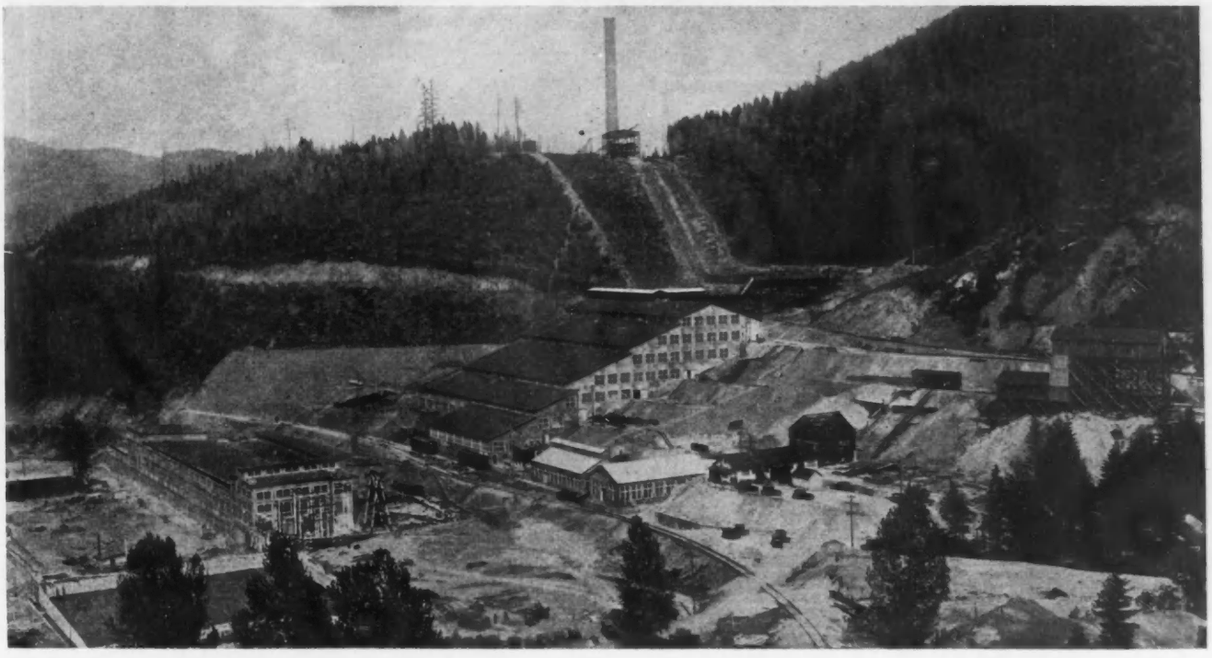
There were over 300 supervisory employees and members of the Pacific Coast Electrical Association in attendance at the San Francisco and Los Angeles meetings, and 115 at the Fresno meeting.

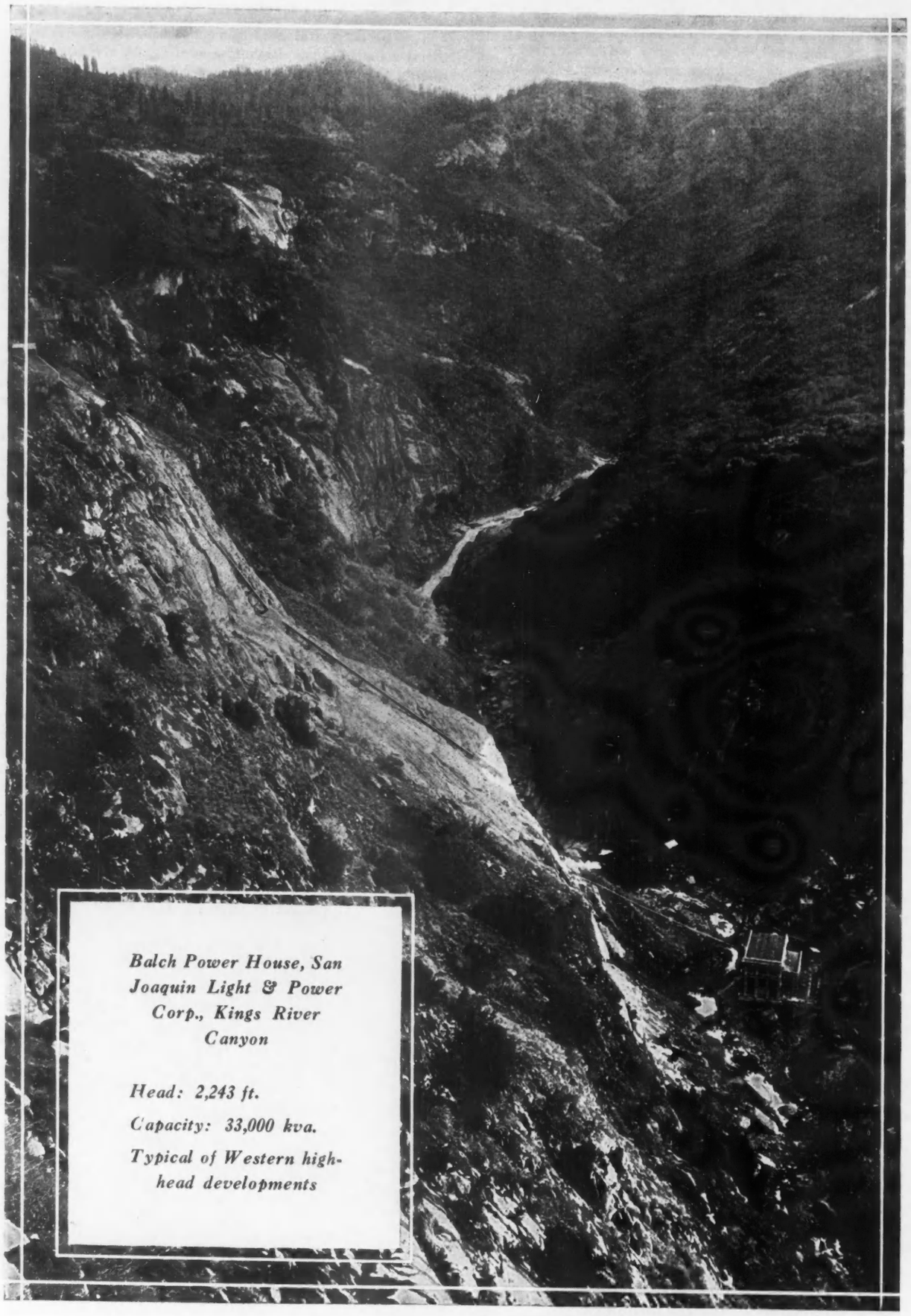
There were nearly 50 in attendance at the San Francisco and Los Angeles committee meetings, and over 30 at the Fresno meeting.

Announcements

Publication No. 92,278, "Additional Sections to the Electrical Safety Orders," has been issued. This contains Orders 7-5050a to 7-5050e, inclusive, and has to do with provisions for preventing accidents due to proximity to high-voltage lines.

Proposed safety requirements for electrical equipment to be used by the public, drafted primarily for employment in the quality improvement program of the Association of Edison Illuminating Companies and published by the Electrical Testing Laboratories, have been distributed. Copies may be obtained by addressing the laboratories.





Balch Power House, San Joaquin Light & Power Corp., Kings River Canyon

Head: 2,243 ft.

Capacity: 33,000 kva.

Typical of Western high-head developments

ELECTRICAL APPARATUS COMMITTEE REPORTS[1]

*Voltage Regulation in Distribution Substations**

Most conspicuous in the trends in voltage regulation today are the growing requirements for regulation on rural and semi-rural feeders, and the decided progress in means of providing bus regulation which tend to make the foregoing requirements economically feasible.

Companies participating in this report are well in accord as to desirable values of regulation, namely, four to five per cent maximum voltage variation on urban feeders, with a somewhat greater range on rural feeders.

Analysis of available figures on regulator failures fails to show any reason why the companies should carry any large number of spare induction regulators for emergency use. The percentages of failures are remarkably low, and speak well for the reliability of this type of equipment.

Individual feeder regulation on voltages over 4,150 volts is not generally practiced locally, but there is a decided interest in bus regulation at voltages in the order of 12,000 volts. This is due to the great number of small substations serving agricultural areas with low load densities. The production of moderately priced automatic tap-changing or load-ratio-control equipment is apparently the answer to problems that have been perplexing several companies.

There is a tendency toward simplification of induction regulator installations, as manifested by the growing number of stations in which separate bypass and disconnecting switches for regulators are omitted.

Generally speaking, power companies are awake to the need for furnishing better voltage regulation to consumers, in order to maintain amicable public relations and to facilitate the improvement of load factor by addition of new load, particularly on suburban and rural feeders. A venture into the field of voltage regulation on lightly loaded feeders demands the exercise of the utmost economy that can be practiced without defeating the original object.

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[1] L. A. Buese, Los Angeles Gas and Electric Corporation, chairman. B. D. Dexter, Pacific Gas and Electric Company, vice-chairman.
Allis-Chalmers Manufacturing Company: B. A. Anderson, W. W. LaBarr, F. H. Searight.
Copperweld Steel Company: C. E. Ingalls.
Farnham & Cunningham: R. E. Cunningham.
Garland-Affolter Engineering Company: P. H. Affolter.
General Electric Company: C. R. Benson, A. Fulton, F. Garrison, O. A. Gustafson, R. F. Monges, J. C. Porter, J. P. Price, W. C. Smith, J. S. Spurck, H. C. Stanley.
Kelman Electric & Manufacturing Company: E. K. Sadler.
Los Angeles Gas and Electric Corporation: G. M. Babcock, C. D. Bidwell, O. L. Irwin, G. A. Riley, J. G. Rollow, F. H. Streit.
Pacific Electric Manufacturing Corporation: A. C. Schwager, E. F. Sixtus, R. Wilkins.
Pacific Gas and Electric Company: J. W. Armstrong, W. R. Baker, C. E. Baugh, C. F. Benham, S. Bowman, I. W. Collins, R. B. Kellogg, J. M. Renfrew, A. Scott, C. W. Smith, H. T. Sutcliffe, A. J. Swank.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow.
San Joaquin Light & Power Corporation: E. J. Crawford, R. C. Denny, R. D. Likely, P. C. McCorkle, E. W. Otto, C. E. Schnell, D. D. Smalley.
Southern California Edison Company Ltd.: J. D. Enefer, J. C. Gaylord, T. J. Lovell, R. B. Pollock, H. L. Sampson, A. P. Sessions, J. H. Vivian, C. W. White.
The Southern Sierras Power Company: A. F. Ayres, M. L. Baden, F. Curtis, R. H. Halpenny, C. N. Parker.
H. B. Squires Company: S. P. Russell.
H. M. Thomas Company: H. M. Thomas.
Westinghouse Electric & Manufacturing Company: R. J. Cobban, A. W. Copley, P. B. Garrett, W. F. Grimes, D. Hall, R. A. Hopkins, R. R. Richey, R. C. Stackhouse, W. L. Winter.

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* Report of subcommittee on economic engineering, electrical apparatus committee, Engineering Section. C. E. Baugh, chairman. J. W. F. Armstrong, K. B. Ayres, C. R. Benson, C. E. Schnell, J. S. Spurck, R. C. Stackhouse, F. H. Streit, R. J. Cobban, Francis Curtis, H. L. Sampson, H. T. Sutcliffe.

AN attempt by a P.C.E.A. subcommittee to make a study of the economics of the voltage regulation of distribution systems brings to the immediate attention of the committee the necessity for making decisions on a variety of questions, some of which are debatable.

First and foremost, the extent of the field that can be covered with propriety by a subcommittee of the apparatus committee must be determined, and some determination must be made of the type of information that might be most useful, as well as of the type of information that is available. The terms "distribution system" and "distribution substation" must be defined, and certain distinctions drawn between the several types of stations and the various voltages used for distribution on the systems involved in the study.

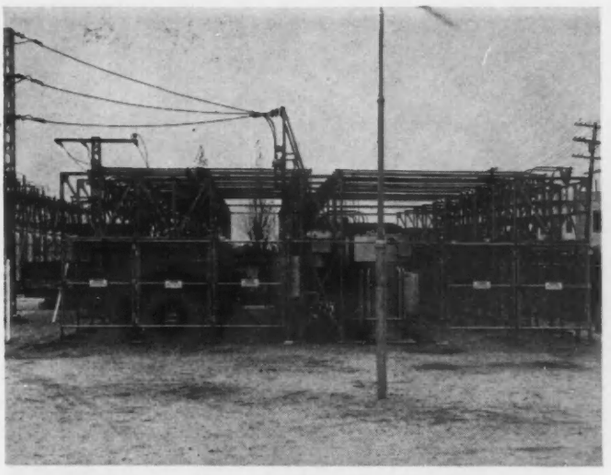

Fig. 1—Three-phase 4,150-volt regulators installed in main and transfer bus structure, Southern California Edison Co.

Analysis of the subject by the committee members has led to certain conclusions which will be noted briefly.

While all members of the committee realize that the question of the economics of voltage regulation of a distribution system involves the questions of regulation of the higher-voltage supply lines feeding distribution substations, and of voltage drop on the feeders and in the transformer banks supplied from the distribution substation, as well as the question of the substation installation designed to correct voltage conditions, it was felt that the committee should confine its work rather closely to the substation phase of the problem for the present. The reasons for this decision were two: to avoid conflict with the work of other committees, and to confine the work to a phase that might be covered in approximate entirety in a reasonable time.

Consideration of the question of what material might constitute useful information brings out the fact that the only committee work that seems desirable at present consists of the collection and correlation of facts as to practices, costs, policies, etc., in connection with regulation. The theory of regulation does not seem to be a proper subject for committee study. An investigation to determine the possible availability of information dealing with the broader aspects of regulation also seems to be of some interest, and particularly so if there should be a desire to continue this subject for another year or more.

The term "distribution system"' is defined as being a system of 20,000 volts or lower potential, from which a number of consumers are served with energy through transformer banks stepping down to the voltage of the consumers' equip-

ment. A "distribution substation" is a substation stepping down from any primary potential to the potential of the distribution system or systems supplied from the station.

For the purposes of the report, substations will be considered in three classes:

1. Urban stations
2. Suburban stations (including the smaller towns)
3. Rural stations

The various distribution voltages are separated into three somewhat distinct classes:

1. Low-voltage class, including systems operated at 2,400 volts, three-wire; 2,400/4,150Y volts, 4-wire; or 4,600 volts, three-wire.
2. Intermediate-voltage class, including systems operated at 7,200 or 6,900 volts, three-wire; or 4,600/8,000Y volts, 4-wire.
3. High-voltage class, including systems operated at 7,200/12,450Y volts, 4-wire; 12,000 volts, three-wire; or higher voltages.

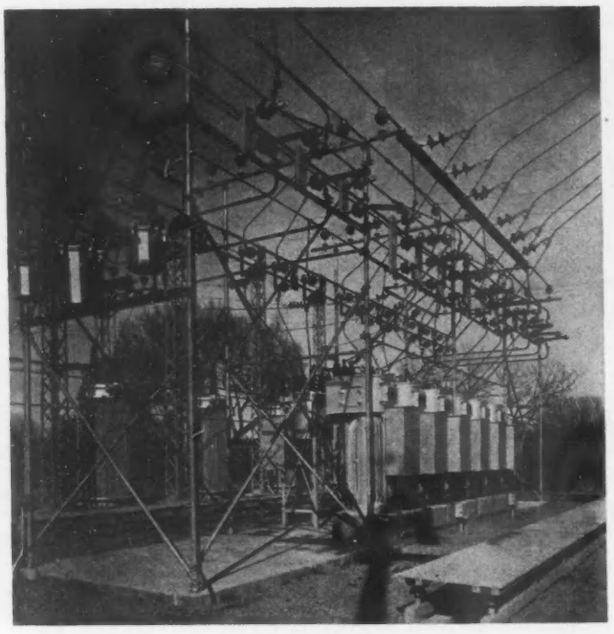

Fig. 2—Outdoor regulators installed in 4-kv. main and transfer bus structure, Pacific Gas and Electric Co.

Distribution substation voltage regulation is discussed from several standpoints, namely (a) general aspects of regulation with respect to the extent of the various applications, policies and practices in determining values of regulation, methods of obtaining information relative to requirements for voltage control, etc., (b) economic and physical aspects of individual feeder regulator applications, and (c) bus voltage regulation.

General Discussion

Application of Regulation in Distribution Stations—

At this point it is of interest to note some figures indicating the extent of regulation as practiced by California companies and the relation between types of substations and the type of regulation provided. Table I shows installed capacities in induction regulators at the various voltages for the several companies, whether used for bus or individual feeder regulation. The table, however, does not include values for regulation furnished by automatic tap changers, synchronous condensers or other apparatus.

Table II shows the prevalence of the various types of regulation for each of the several companies and for each type of station.

Throughout this report Pacific Gas and Electric Co. figures do not include Great Western Power Co. properties.

As shown in Table II, regulation of feeders from urban substations is practically universal practice, and in general is of the highest type, that is, is secured by the use of separate automatic regulators, either single-phase or three-phase, on individual feeders. The use of three-phase regulators for this type of service is confined to one company, the remainder definitely preferring single-phase equipment. In suburban stations we again find that some form of regulation is provided in practically all cases, but that, as might be expected, there is a tendency for a somewhat lower class of regulation, the use of some form of bus regulation being rather extensive. An average of about one-third of the feeders in rural areas are provided with some form of regulation, although one company reports no regulation on rural feeders. Bus regulation is the most prevalent type for this latter class of feeders.

TABLE I—Total Installed Capacity in Induction Regulators.
(Expressed in Kva.)

Company	Feeder Voltage					Total on all Voltages
	2,300	4,000	4,600	6,900	12,000	
L. A. G. & E. Corp...	5,000	15,000	....	....	.....	20,000
S. C. E. Co.....	....	30,000	....	....	1,000	†31,000
S. S. P. Co.....	....	.....	....	....	.....	3,029
S. D. Con. G & E. Co.	350	6,300	....	....	4,000	10,650
S. J. L. & P. Corp....	*No figures available.					
P. G. & E. Co.....	3,586	50,761	892	162	1,485	56,886
Total.....	8,936	102,061	892	162	6,485	121,565

*S. J. L. & P. Corp. figures do not segregate induction regulators as distinguished from tap-changers or other forms of regulation but indicate that there is a total installed capacity of approximately 23,600 kva. of regulation on their system.

†Note that an appreciable portion of S. C. E. Co. output is delivered to municipalities for resale.

The effect of feeder voltage rating on the question of regulation seems to be merely a matter of the type of regulation to be provided, inasmuch as all companies having higher-voltage feeders find it necessary to furnish regulation in many cases. These higher-voltage feeders are found chiefly in rural territory and the comments in the paragraph above apply very largely.

The only tendencies toward modification of established practices are the growth of regulation on rural feeders and the swing toward bus regulation in suburban and particularly in rural territories. This latter tendency is of great importance and will be discussed more fully later. The San Diego Consolidated Gas & Electric Co. reports a tendency toward the use of more individual feeder regulator equipments.

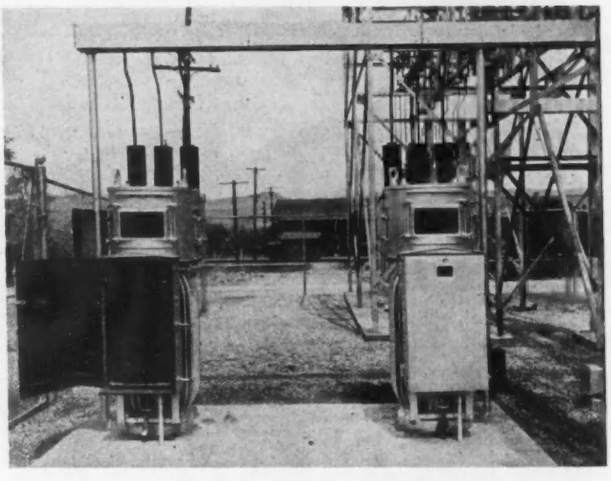

Fig. 3—Regulators on 2,400-volt three-wire feeder, The Southern Sierras Power Co.

TABLE II—Prevalence of Various Types of Regulation in Per Cent of Total Number of Regulated Feeders.

Type of Regulation	P. G. & E. Co.			S. C. E. Co.			S. S. P. Co.			S. D. Con. G. & E. Co.			L. A. G. & E. Corp.			S. J. L. & P. Corp.		
	Urban	Sub.	Rural	Urban	Sub.	Rural	Urban	Sub.	Rural	Urban	Sub.	Rural	Urban	Sub.	Rural	Urban	Sub.	Rural
Ind. Feeder..	90	22	17	100	50	8	45	7	00	98	34	00	96	..	..	14.5	00	00
Bus Reg.....	1—	45	20	00	50	90	38	39	00	00	66	35	00	..	..	76.5	53.5	35
No. Reg.....	10	33	63	00	00	2	17	54	100	2	00	65	4	..	..	9.0	46.5	65

Permissible Voltage Variation on Regulated Feeders—

All companies report the use of 10 per cent regulation each way from neutral with a total regulation of 20 per cent, except in special cases involving the connection of regulators for double current capacity and 5 per cent regulation, plus and minus. This holds true for all classes of stations and all voltages.

The question of minimum voltage variation at consumers' services, under present conditions, has not been covered by two of the companies participating in this report. Two companies consider a variation of 5 per cent on all types of feeders as being satisfactory and regulate for this condition. They feel that a 5 per cent variation is reasonable and that it can in general be economically attained. It might be added that one of these companies has a rather small percentage of strictly rural load and the other does not practice regulation of rural feeders. Another company with a large rural load, limits the voltage variations in urban and suburban territory to 5 per cent maximum (3.3 per cent plus and 1.7 per cent minus rated lamp voltage) and in rural territory to 9 per cent, with an actual variation in some of the heavier load areas averaging from 1.7 per cent to 3.3 per cent. The sixth company considers a voltage variation of 9 per cent on urban load as being the maximum permissible, this variation being divided between 6 per cent below and 3 per cent above the rated lamp voltage. This company feels that a voltage variation of 4 per cent (2 per cent plus and minus rated lamp voltage) constitutes a desirable value of regulation, and one that should be attained in urban areas.

Regulation of long rural feeders by the use of individual feeder regulators can seldom be justified on an economic basis, whereas the use of an inexpensive form of bus regulation can be in many cases. In cases where no form of regulation can be justified economically, the factors of competition or consumers' relations are of sufficient importance to dictate that some improvement in voltage conditions be made. The entrance of regulated service into areas where it has not been previously provided is often the means of obtaining increased revenue in new load entirely out of proportion to the direct increase, due to the sustaining of a proper maximum voltage.

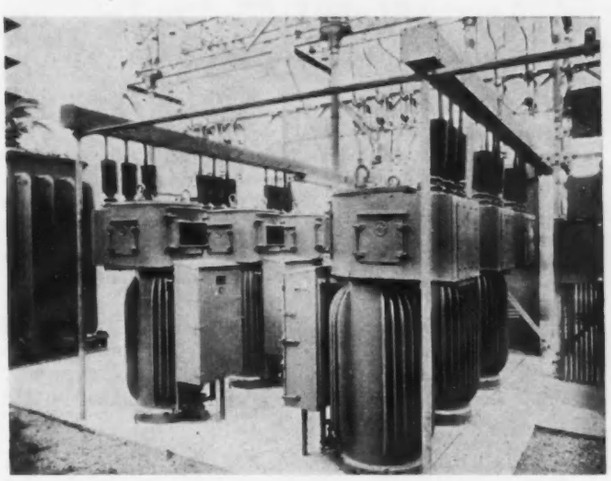

Fig. 4—Regulators on 4,000-volt four-wire feeders, installed in main and transfer bus structure, The Southern Sierras Power Co.

Maintenance of Bus and Feeder Voltage Records—

Practices in the making of load studies and the keeping of voltage records on feeders vary widely between the several companies. The Los Angeles Gas and Electric Corp. and the San Diego Consolidated Gas & Electric Co. alone make a practice of taking periodic voltage checks at feeder load-centers. The former makes a check of voltage conditions on each feeder with a graphic voltmeter at least once a year and in addition at times of shifting load from one feeder to another or in response to consumers' complaints. The latter company makes weekly graphic voltmeter checks of voltage at feeder load-centers on practically all feeders. The Pacific Gas and Electric Co. is considering the installation of permanent meter boxes on each of a number of feeders in certain areas to facilitate the installation of portable graphic voltmeters during peak load periods, but so far has no fixed policy in this respect.

The remaining companies make voltage checks at feeder load-centers or at other points only at such times as investigation of consumers' complaints dictates the necessity, or at such times as conditions indicate the desirability. Portable graphic ammeters and voltmeters are used to check voltage and loading conditions.

The Pacific Gas and Electric Co. maintains, in general, a continuous record at substations of voltages on each regulated bus or on each regulated feeder, as the case may be, using for this purpose a graphic voltmeter with a voltmeter switch for transferring from one phase to another. Use is made of these charts by the substation and distribution departments as a check on regulation and feeder characteristics. The Los Angeles Gas and Electric Corp. maintains recording voltmeters on one phase of each station bus, to give a continuous record of bus voltage, and in addition equips its supervisory stations with recording instruments arranged to take periodic records of individually regulated feeder loadings and voltages. These records are made semi-monthly and the information obtained is kept on the station log sheets. No further use is made of the charts except in case of specific voltage troubles. The Southern California Edison Co. takes voltage charts about twice a month on each regulated feeder, and the remaining companies keep no record of station voltages on regulated feeders. The San Joaquin Light & Power Corp. does, however, maintain a continuous record of voltages on regulated buses, which constitute the bulk of their station regulation.

Effect of Supply-Line Regulation on Substation Regulation—

Very little information is available as to the effects of regulation of substation supply lines on feeder regulation. The Southern California Edison Co. probably maintains as uniform a voltage on the high side of distribution substation transformer banks as any company in this area. They now operate 450,000 kva. in synchronous condenser capacity, of which 200,000 kva. is applied more or less directly to voltage regulation and power factor correction to reduce losses, at a cost of about $700,000. If it were not for this capacity in synchronous condensers, which tends to hold a flat voltage on 66-kv. buses, the Southern California Edison Co. estimates that it would be required to spend a much larger sum for regulation on 16-kv. and 11-kv. lines. It does not allow for any appreciable voltage variation on station buses other than that caused by transformer regulation.

The Pacific Gas and Electric Co., with a less concentrated load and considerably less synchronous condenser capacity,

finds the over-all regulation of supply circuits and station transformers varying from 2 per cent to 10 per cent, the lower value in the metropolitan areas supplied by heavy 11-kv. networks and the higher values in rural areas supplied by 60-kv. transmission lines. It is evident that in small rural stations located at some distance from heavy concentrations of energy, an appreciable part of the feeder regulator range must be used in correcting for high line regulation.

The Los Angeles Gas and Electric Corp. regulates its 33-kv. transmission system to some extent by hand, carrying a higher system voltage at times of heavy load. An average figure for the portion of feeder regulation required to compensate for supply line drop and station transformer regulation on its system is 2 per cent, in addition to the regulation furnished from generating stations.

In passing from this subject, it might be noted that the percentages of regulation for station transformers as specified by the various companies are as follows:

L. A. G. and E. Corp.—1.5 per cent at 100 per cent P. F., 4.8 per cent at 80 per cent P. F.

S. C. E. Co.—1,000 kva., 3.5 per cent.
2,000 kva., 4.0 per cent.
3,000 kva., 5.0 per cent.
(All at 80 per cent P. F.)

S. D. Con. G. & E. Co.—No regulation specified.

S. J. L. & P. Corp.—Not to exceed 1.5 per cent at 100 per cent P. F. or 3.5 per cent at 80 per cent P. F.

S. S. P. Co.—No information.

P. G. and E. Co.—7,200/12,450Y-volt primary:
Not to exceed 4.5 per cent at 80 per cent P. F.
31,215/54,000Y-volt primary:
No regulation specified.
Impedance specified as not to exceed 6 per cent, regulation being approximately 1 per cent at 100 per cent P. F. and 4.5 per cent at 80 per cent P. F.

Standardization of Requirements—

Standardization of regulator requirements as to size and type is practiced by five companies, all of whom confine their requirements to as small a variety as possible, with exceptions in special cases only. This information is tabulated in Table III.

Spare Regulators—

From a service standpoint, induction regulators seem to be rather dependable, as the practices with respect to provision of spare regulators either in a central warehouse or in substations indicate a limited need for spares, in comparison with the number of regulators in service.

Two companies stock no spares at all and claim to have experienced no particular inconvenience in this respect. Of the four remaining companies, three carry a very few spares in a central warehouse or at scattered points in the metropolitan area, this number representing from one to three per cent of the total of installed regulators. The San Diego Consolidated Gas and Electric Co. installs a bank of transfer regulators in urban stations, with provision for transferring any feeder to this bank. Spare regulators, so installed, constitute from nine to sixteen per cent of the total in each station.

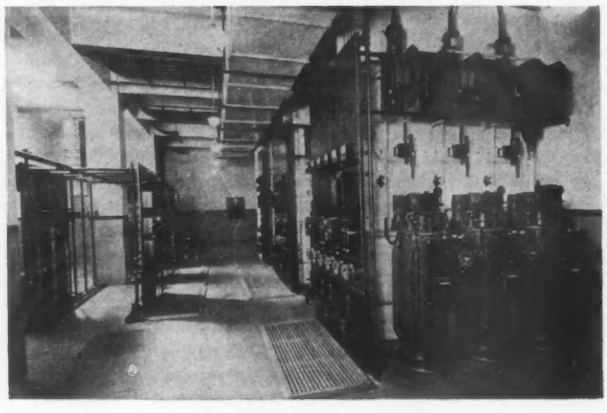

Fig. 5—Indoor regulators installed in connection with double bus, Pacific Gas and Electric Co.

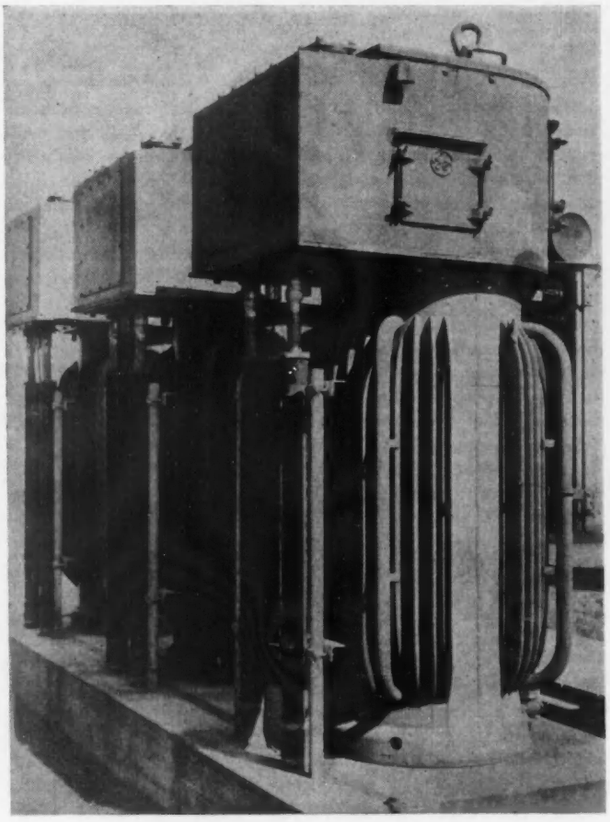

Fig. 6—Outdoor regulators installed in connection with main and transfer buses with no exposed leads in station yard. Note wiped connections to regulators. Pacific Gas and Electric Co.

TABLE III—Standardization of Regulator Requirements.

Company	Size in Amp.	Per Cent Regulation	Voltage	Phase	Cooling	Application
P. G. & E. Co.....	150/300	10/5%±	2,400	Single	Self	Indoor
	200/400					or
	300/600					Outdoor
L. A. G. & E. Corp....	250/500	10/5%±	2,400	Single	Self	Indoor
S. C. E. Co.....	100/200	10/5%±	4,150	Three	Self	Outdoor
S. S. P. Co.....	100/200	10/5%±	2,400	Single	Self	Outdoor
	150/300	10/5%±				
	200/400	10/5%±				
	400	10%±				
S. J. L. & P. Corp.....	None	10/5%±	2,400	Single	Self	Outdoor

The major reasons for not providing more spare regulators are: (a) that provisions are always made for taking regulators out of service and supplying unregulated energy to the feeder or feeders; and (b) that cases of regulator trouble requiring removal from service are remarkably infrequent. The San Diego Consolidated Gas and Electric Co. reports eight cases of trouble with regulators in eight years, in four of which the feeders were supplied over transfer regulators, the other four cases requiring supply of unregulated service until the trouble was remedied.

Failures in Induction Regulators—

Data on actual regulator failures as shown below serves to illustrate the points made above:

Company	Failures in per cent of installed regulators
P. G. & E. Co.	1.24% in 3 years
S. C. E. Co.	0.54% in 1930 0.25% in 1931
S. D. Con. G. & E. Co.	2,300-volt, single-phase; 4% in 8 years 4,000-volt, three-phase; 25% in 8 years 12,000-volt, three-phase; 7% in 8 years
S. S. P. Co.	3% in 4 years.

The Pacific Gas and Electric Co. segregates its regulator failures for the past three years as follows:

Motor failures—6
Winding failures—18 (1 due to 60 kv. contact)
Mechanical failures—9
Lead failures—4 (2 due to external causes)
Total failures—37 or 1.2%

No other segregation of failures is available.

Individual Feeder Regulation[2]

Regulation in Low-Voltage Class:

In discussing types of regulators and their application to individual feeder regulation, it becomes apparent, on turning back to Table I, that little importance attaches to feeders of voltages higher than 4,150 volts, as far as volume is concerned.

On 2,400-volt feeders there is little to choose between single-phase and three-phase regulators, the latter being very slightly lower in first cost based on feeder kva., and requiring somewhat less floor space for installation.

On 4,150-volt, four-wire circuits there is a very decided preference for three single-phase regulators per circuit in place of three-phase regulators, especially in urban and suburban areas. The only exception to this is the Southern California Edison Co., which consistently makes use of three-phase 4,150-volt regulators on the basis of economy and satisfactory results. The use of single-phase rather than three-phase regulators for 4,000-volt, four-wire circuits has the advantages of lower first cost, greater flexibility, greater ease in cutting in and out of service by means of bypass and disconnecting switches, more accurate regulation on unbalanced loads, and less embarrassment resulting from the failure of a single regulator. No definite data is available as to the relative installation and maintenance costs of single-phase and three-phase regulators. Speaking only comparatively, however, the installation cost for three single-phase regulators is slightly higher than that for a three-phase regulator, due to the greater floor space and somewhat greater amount of wiring required.

[2] San Joaquin Light & Power Corp. not included in this discussion, as they have a limited number of individually regulated feeders.

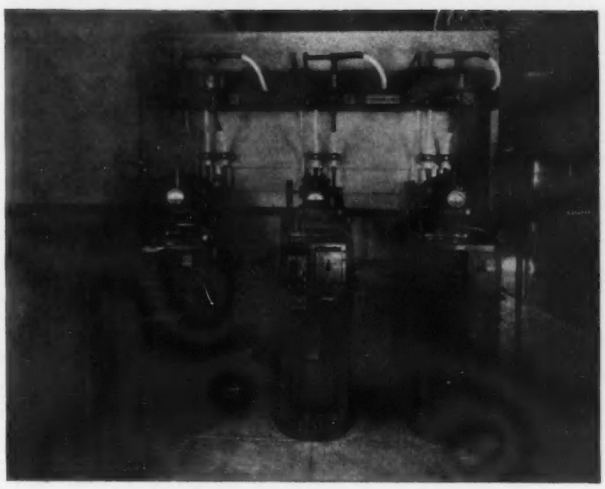

Fig. 7—Indoor regulators installed in connection with main and transfer buses, Pacific Gas and Electric Co.

The experiences of two companies having both single-phase and three-phase regulators in service indicate that the former are somewhat more reliable than the latter and that maintenance costs, especially in case of burnouts, are lower. The only definite information on this point that is available is from the Pacific Gas and Electric Co. On their system eight failures, or 22 per cent out of a total of 37 failures in three years occurred on three-phase regulators, although the number of three-phase regulators is only 3 per cent of the total of all regulators in service. A mitigating circumstance is that all of the three-phase regulators had been in

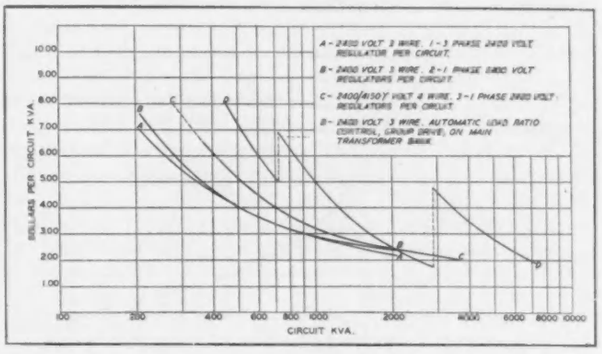

Fig. 8—Cost comparison of regulation on 2,400-volt three-phase circuits

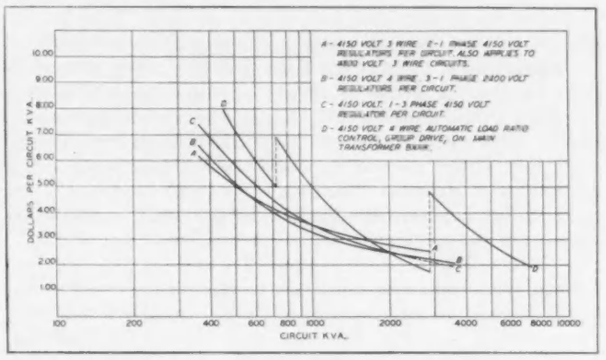

Fig. 9—Cost comparison of regulation on 4,150-volt three-phase circuits

service a number of years, whereas a number of the single-phase regulators were of later design.

Comparative costs of the various types of regulation as applied to 2,400-volt and 4,150-volt circuits are shown in Fig. 8 and 9 respectively. Induction regulator costs in these curves are figured on regulator prices f.o.b. factory for indoor regulators with a range of ten per cent buck and ten per cent boost, complete with current and potential transformers and with accessories mounted on a panel attached to the regulator case. All costs are expressed in dollars per kva. of circuit, so that for a given circuit-kva. they are strictly comparable. Single-phase outdoor regulators in the above voltage ratings, with a self-contained power supply for the operating motor, cost from $190 to $250 more each than indoor, depending on the size of the regulator. Three-phase outdoor regulators cost from $220 to $280 more than indoor.

Installation costs are not available to any great degree and depend very largely upon whether the installation is indoor or outdoor and upon the amount of incidental apparatus and equipment used. Single-phase outdoor regulators of moderate sizes can be installed for approximately $150 per bank of three, if no disconnecting and bypass switches

chargeable to the regulators are used, as is customary with several companies. Single-phase indoor regulators can be installed for prices ranging from $400 per bank of three for the simpler types of construction where no disconnecting and bypass switches are used, to $800 for the more elaborate assemblies with extensive barriers and with separate disconnecting and bypass switches. Outside of the exceptions noted, these costs are based on comparable installations.

Regulation in Intermediate and High-Voltage Classes—

Companies on the Pacific Coast have had comparatively little experience with individual regulation on feeders of the intermediate and high-voltage classes. The Southern California Edison Co. uses three-phase regulators on three 11-kv. feeders only, their 66-kv. bus regulation being sufficiently good for the remainder of their 11-kv. and 16.5-kv. feeders. The San Diego Consolidated Gas & Electric Co. has an installed capacity of 4,000 kva. in three-phase 12-kv. regulators, used either as bus regulators or as feeder regulators on three-wire circuits. The Pacific Gas and Electric Co. has an installed capacity of 162 kva. in 6,900-volt single-phase regulators and no 12,000-volt individual feeder regulation.

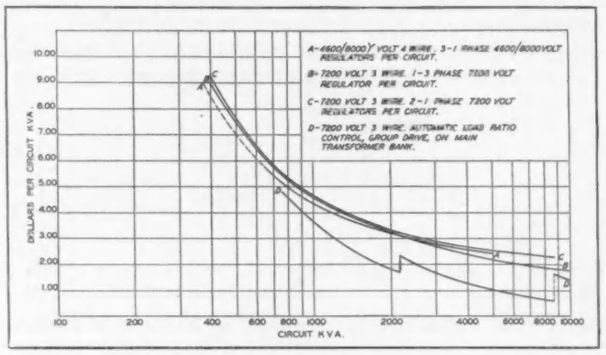
A-4600/8000Y VOLT 4 WIRE, 3-1 PHASE 4600/8000 VOLT REGULATORS PER CIRCUIT.
B-7200 VOLT 3 WIRE, 1-3 PHASE 7200 VOLT REGULATOR PER CIRCUIT.
C-7200 VOLT 3 WIRE, 2-1 PHASE 7200 VOLT REGULATORS PER CIRCUIT.
D-7200 VOLT 3 WIRE, AUTOMATIC LOAD RATIO CONTROL, GROUP DRIVE, ON MAIN TRANSFORMER BANK.
DOLLARS PER CIRCUIT K.V.A.
CIRCUIT K.V.A.

Fig. 10—Cost comparison of regulation on 7,200-volt and 8,000-volt three-phase circuits

Fig. 10 and Fig 11 show comparative cost of several types of regulating equipment that may be used in the intermediate and high-voltage classes, respectively. In connection with these curves, it should be noted that the use of 2,400-volt regulators with series and shunt transformers, either single-phase or three-phase, is considerably less expensive than the use of single-phase or three-phase 7,200/12,450Y or 12,450-volt regulators. A late development that should receive serious consideration is the three-phase regulating auto-transformer with automatic tap-changing equipment. Available prices for this apparatus are shown in Curve (F),

Fig. 10 and Fig. 11 show comparative cost of several types

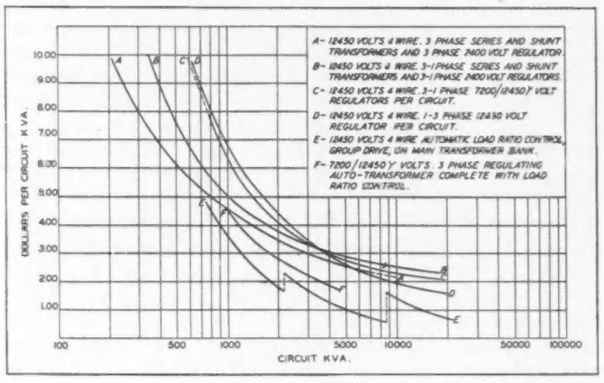
A-12450 VOLTS 4 WIRE, 3 PHASE SERIES AND SHUNT TRANSFORMERS AND 3 PHASE 2400 VOLT REGULATOR.
B-12450 VOLTS 4 WIRE, 3-1 PHASE SERIES AND SHUNT TRANSFORMERS AND 3-1 PHASE 2400 VOLT REGULATORS.
C-12450 VOLTS 4 WIRE, 3-1 PHASE 7200/12450Y VOLT REGULATORS PER CIRCUIT.
D-12450 VOLTS 4 WIRE, 1-3 PHASE 12450 VOLT REGULATOR PER CIRCUIT.
E-12450 VOLTS 4 WIRE AUTOMATIC LOAD RATIO CONTROL, GROUP DRIVE, ON MAIN TRANSFORMER BANK.
F-7200/12450Y VOLTS, 3 PHASE REGULATING AUTO-TRANSFORMER COMPLETE WITH LOAD RATIO CONTROL.
DOLLARS PER CIRCUIT K.V.A.
CIRCUIT K.V.A.

Fig. 11—Cost comparison of regulation on 7,200-/12,450Y-volt three-phase circuits

indicate that this form of regulation is the least expensive of any adapted to feeder regulation. The tap-changing equipment covered by the curve provides twenty per cent regulation in eight 2½ per cent steps, which is entirely adequate for the long rural feeders where this type of regulation finds its most useful application. Feeders of this type need not be regulated more closely than by 2½ per cent steps, inasmuch as the drop from point to point on a feeder can vary more than 2½ per cent with changing load conditions without affecting station voltage.

TABLE IV—Average relation between capacity in stepdown transformers and feeder regulators in distribution substations.

Company	Reg. Cap. in % of Transf. Cap.			
	Urban	Suburban	Rural	Total
P. G. & E. Co.	79	79	95	80
S. D. Con. G. & E. Co.	100–130	60–100	100	...
S. C. E. Co.	...	..	...	110
L. A. G. & E. Corp.	114	..	...	114

An analysis of individual feeder regulation from the standpoint of the relation between installed regulator capacities and stepdown transformer-bank capacities, on the basis of circuit-kva. is shown in Table IV. Figures indicate that an excess capacity of from ten to fifteen per cent in regulation is normal in completed installations.

Load Balancing—

An ever-present problem in feeder regulation is the maintaining of proper current balance between phases of three-phase feeders. Only three companies report on their practices in connection with this problem, but their efforts are probably representative of the other companies. The Pacific Gas and Electric Co. endeavors to maintain an unbalance not exceeding fifteen per cent on three-wire circuits with two regulators per circuit, though this must be exceeded in many cases. Unbalance has been reduced to as low as ten per cent in certain cases where a special effort has been made. The Los Angeles Gas and Electric Corp. considers 50 amp. the maximum permissible current unbalance on three-wire circuits.

The Southern California Edison Co. considers 50-amp. neutral current on four-wire circuits a maximum and endeavors to keep it below 25 amp. The Los Angeles Gas and Electric Corp. allows a maximum neutral current on four-wire circuits of 50 amp. The Pacific Gas and Electric Co. makes a determined effort to limit neutral current to 20 amp. on four-wire circuits, though this result cannot be achieved in every case. It should be noted at this point that in the case of common-neutral circuits the power companies have tentatively agreed not to exceed 50 amp. in the neutral return.

Routine methods of preventing excessive unbalance by watching phase loadings and adding new load or shifting existing transformers to suit are in use by all companies and are of no particular interest. The Pacific Gas and Electric Co. has gone further in a few cases and prepared feeder diagrams showing the various classes of loading on the feeder under consideration, after which each class of load has been balanced as far as possible within itself, to eliminate disturbance to the circuit balance with daily and seasonal changes in loading. This method of balancing has given exceptionally good results where it has been practiced.

Line Drop Compensation—

Two companies consistently practice back-feeding to improve compensation on four-kv. feeders, the Southern California Edison Co. in many cases and the Los Angeles Gas and Electric Corp. on all overhead feeders. The latter company, in general, builds four laterals radiating from a point designated as the load center. One lateral is carried back

toward the substation on the pole line that carries the feeder to the load center, and the additional expense for back-feeding is limited to wire, insulators, and hardware. Excellent results are claimed for this method of construction, particularly on long heavily loaded feeders where considerable com-

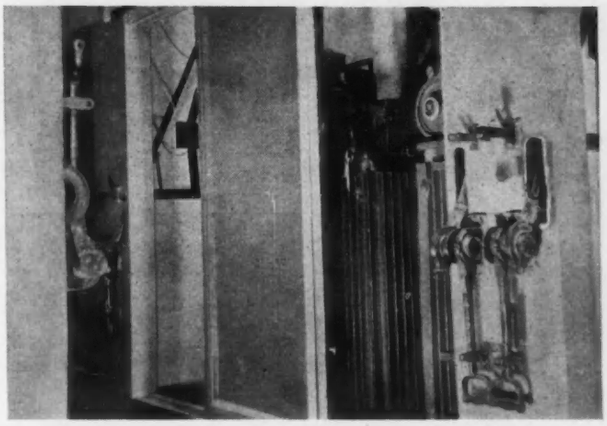

Fig. 12—Regulators on 4-kv. 4-wire circuit installed in concrete cells, Los Angeles Gas and Electric Corp.

pensation is required. Back-feeding is not practiced on underground feeders, as they are of relatively large copper size and of low reactance and are comparatively short.

Physical Aspects of Regulator Installations—

There is a decided tendency in all companies so to install regulators as to eliminate the necessity for equipping them with separate bypass and disconnecting switches for taking regulators out of service. Companies that make extensive use of main and transfer buses, parallel two feeders over one bank of regulators at times of light load and use the feeder breaker to de-energize the bank being taken out of service. The connection also permits the furnishing of unregulated service over the transfer bus. This connection is shown in Fig. 13 (a), (b) and (c). The Los Angeles Gas and Electric Corp., using a double-bus diagram with two breakers per circuit on four-kv. urban circuits, connects each bank of regulators to one bus only. The other bus supplies the feeder with unregulated voltage and it is a simple matter to transfer a feeder from one bus to the other, using the first feeder breaker to de-energize the regulators. This connection is shown in Fig. 13 (d). The Pacific Gas and Electric Co., in stations equipped with a double bus with two breakers per circuit, installs bypass and disconnecting switches to permit removal of regulators from service as shown in Fig. 13 (e). The San Diego Consolidated Gas & Electric Co. installs regulators in connection with the transfer breaker in urban stations with main and transfer buses, as shown in Fig. 13 (f), and is thereby able to furnish regulated service over a feeder even when the regulators normally connected to the feeder are out of service for maintenance.

All companies using air break disconnecting and bypass switches with regulators, install oil circuit breakers in the exciting winding either on the line end or neutral end, to interrupt the exciting current when taking the regulator out of service. These breakers are either operated manually or are interlocked with other switches to open automatically in proper sequence. Past experience with regulators of 34½-kva. or higher capacity has shown that the interruption of regulator exciting current in air sometimes leads to arcs which communicate with grounded parts of the structure and may blind the operator and cause serious disturbances to service. Connections for the breakers are indicated in Fig. 13 (d) and (e).

The Pacific Gas and Electric Co. is the only one using case grounding relays to trip and lock out feeder breakers in case of regulator faults. Their contention, particularly in stations where the feeders are equipped with periodic reclosing devices, is that a breaker should not be reclosed on a regulator fault where the short-circuit current might be high enough to damage the regulator seriously or to overstress the breaker on repeated operations. Relays with both

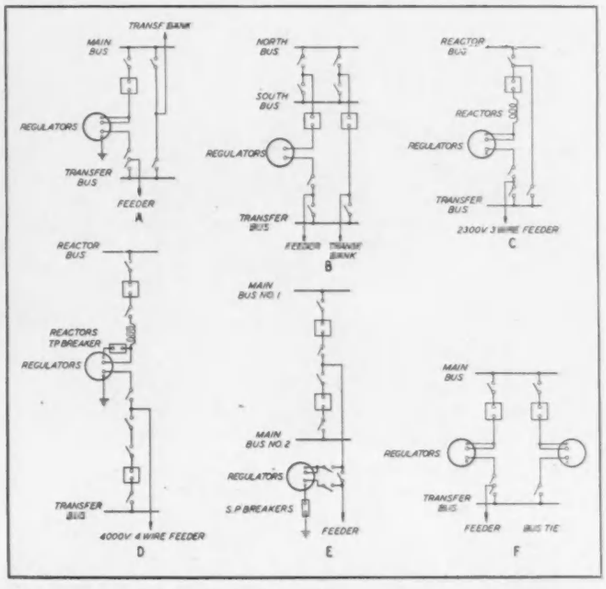

Fig. 13—Typical diagram of feeder regulator applications (a) with main and transfer buses, used by Pacific Gas and Electric Co., San Diego Consolidated Gas & Electric Co., The Southern Sierras Power Co., (b) with main and transfer buses, used by Southern California Edison Co. Ltd., (c) with main and transfer buses, used by Los Angeles Gas and Electric Corp., (d) with two main buses, used by Los Angeles Gas and Electric Corp., (e) with two main buses, used by Pacific Gas and Electric Co., (f) with main and transfer buses, used by San Diego Consolidated Gas & Electric Co.

circuit-opening and circuit-closing contacts are used, hand reset and with operation indicators, and are so wired into the control circuits that the breaker is tripped and cannot be reclosed either manually or automatically until the relay is reset. One relay is used for a bank of three regulators and the cost of installation is a small fraction of the total cost of the bank. No exact idea of the benefit obtained from this device is procurable, although it is stated that prior to their use there were several severe cases of trouble on automatic reclosing feeders that would have been prevented had they been installed.

Bus Regulation

Application—

Companies having any considerable rural or semi-rural load are vitally interested in the subject of bus regulation. The normal rural feeder does not return enough revenue to a power company to justify individual feeder regulation and such regulation as is furnished must be secured from some form of bus regulation. Bus regulation is as satisfactory as individual regulation when feeder voltage drop is low or when all feeders from a bus are of similar lengths and have similar loading characteristics. In cases where rural and small town feeders are fed from the same bus, it is often possible to separate the feeders into two groups and regulate each bus section independently. Another possibility, in cases where a station is located in a small town and is equipped for one town feeder and four or five rural feeders of similar characteristics, is to regulate the bus with ten per cent plus or minus regulation and superimpose on this regulation five per cent plus or minus regulation on the single town feeder.

A typical station illustrative of this point has an installed transformer capacity of 4,500 kva. Individual feeder regulation requires four banks of 48-kv. regulators and one bank of 36-kva. regulators, at an installed cost of approximately $21,000. Four feeders supply a rural load and one feeder supplies the town in which the station is located. Assuming

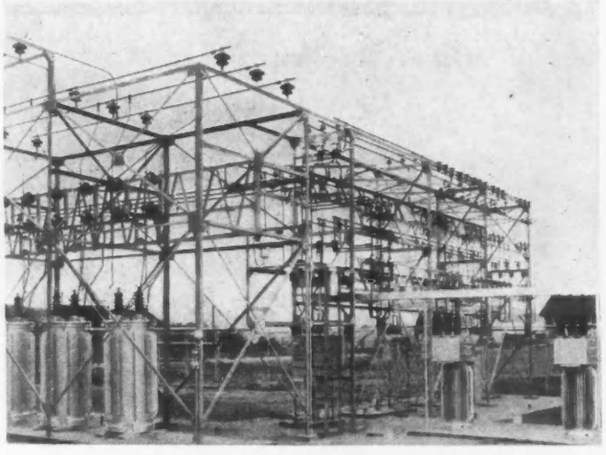

Fig. 14—Installation for regulating 2,400-volt three-wire bus, The Southern Sierras Power Co.

proper loading conditions on the four rural feeders, the five banks of feeder regulators might be replaced with bus regulators of 450-kva. capacity and one bank of five per cent plus or minus 18-kva. regulators for the town feeder at a total installed cost of $15,000. The saving in this typical case is approximately 30 per cent. An investigation of cases of this type will generally lead to an over-all economy without a material sacrifice in quality of service.

Economic Features—

The economy of various types of equipment particularly

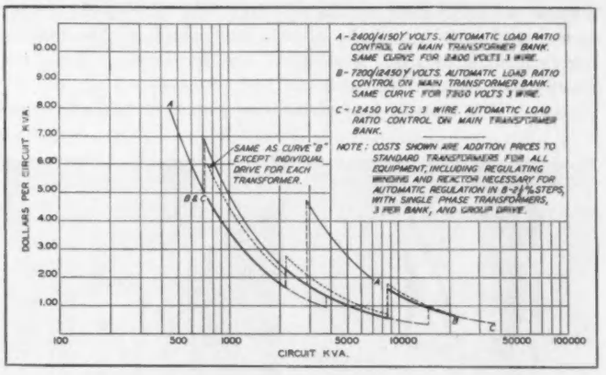
A - 2400/4150Y VOLTS. AUTOMATIC LOAD RATIO CONTROL ON MAIN TRANSFORMER BANK. SAME CURVE FOR 2400 VOLTS 3 WIRE.
B - 7200/12450Y VOLTS. AUTOMATIC LOAD RATIO CONTROL ON MAIN TRANSFORMER BANK. SAME CURVE FOR 7200 VOLTS 3 WIRE.
C - 12450 VOLTS 3 WIRE. AUTOMATIC LOAD RATIO CONTROL ON MAIN TRANSFORMER BANK.
NOTE: COSTS SHOWN ARE ADDITION PRICES TO STANDARD TRANSFORMERS FOR ALL EQUIPMENT, INCLUDING REGULATING WINDING AND REACTOR NECESSARY FOR AUTOMATIC REGULATION IN 8-2½% STEPS, WITH SINGLE PHASE TRANSFORMERS, 3 PER BANK, AND GROUP DRIVE.
SAME AS CURVE "B" EXCEPT INDIVIDUAL DRIVE FOR EACH TRANSFORMER.
DOLLARS PER CIRCUIT KVA.
CIRCUIT KVA.
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
100
500
1000
5000
10000
50000
100000

Fig. 15—Cost comparison of regulation on three-phase circuits at various voltages, using automatic load-ratio control on single-phase transformers

adaptable to bus regulation varies with the voltage. In general, there are five types of equipment available: (a) induction regulators, single-phase or three-phase; (b) automatic tap-changing or load-ratio-control equipment built into the low-voltage side of the station transformers; (c) same as (b) except built into the high-voltage side of the station transformers where the voltage permits; (d) automatic tap-changing auto-transformers where main transformers are not so equipped; and (e) synchronous condensers. This report does not intend to deal with the use of synchronous condensers for regulation. It is axiomatic that step-by-step regulation as furnished by tap-changers will probably be suitable wherever bus regulation is suitable, as nothing more than a compromise with perfect regulation can be expected from anything less than individual feeder regulators.

At 2,400, 4,150, and 4,600 volts, induction regulators are less expensive than tap-changing equipment on the low-voltage side of the transformers, except for a fairly small range of capacities. At 7,200, 8,000, and 12,450 volts, tap-changing equipment is less expensive than induction regulators, the economy becoming more noticeable at the higher voltages. A few figures for automatic tap-changing regulating auto-transformers are available, and are shown in Curve (F), Fig. 11. This type of equipment is useful for feeder regulation or for bus regulation where the main transformers are not fitted with tap-changing equipment, and is more economical than high-voltage induction regulators. The comparisons made in this paragraph are shown graphically in preceeding curves.

Fig. 15 shows comparative costs of tap-changing equipment at the various distribution voltages. These costs are expressed as addition costs to standard single-phase transformers, for banks of three transformers each, with a group drive for each bank. Prices for individual drive are as indicated, and are slightly higher. Prices for tap-changing equipment on three-phase transformers are slightly lower than those shown for three transformers with group drive. Four single-phase tap-changers may be operated from one drive mechanism, the increase in cost per bank being between 20 and 25 per cent. The peculiar stepped shape of the curves is due to the jumps between the ampere capacities of 1-100, 101-400 and 401-1,000 amp. It should be noted here that Curves (B) and (C) cover costs of tap-changing equipment on the high-voltage side of transformers rated 7,200 volts or 12,450 volts, as well as on transformers of these same low-voltage ratings. Station transformers stepping down to lower bus voltages, and equipped with tap-changers on the high-voltage side, provide bus regulation at lower cost than do induction regulators on buses falling in the low-voltage class, for circuits of 1,200 kva. and higher capacities. It will be interesting to observe the possibilities, in special

cases, of combining bus regulation by means of tap changers with induction regulators on individual feeders requiring separate compensation.

Standard tap-changing equipment provides a total range of regulation of twenty per cent in eight 2½ per cent steps, which seems to be entirely adequate. The Pacific Gas and Electric Co. has built a number of tap-changers of their own design with ten to two per cent steps, but does not feel that there is any inherent disadvantage in the use of the standard manufactured equipment.

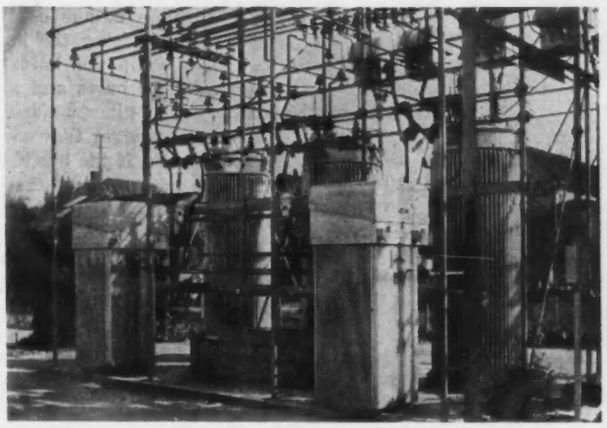

Fig. 16—Installation for regulating 2,400-volt three-wire bus, San Joaquin Light & Power Corp.

Companies in general have not had enough experience with the latest types of tap-changing equipment to enable anyone to venture an opinion as to their reliability or to predict what maintenance costs might be; it is only possible to say that there is no reason at present to expect trouble.

All companies making use of bus regulation make a practice of using compensation to provide a higher bus voltage at times of heavy load than at times of light load.

*Preventive Engineering**

The following report attempts to present the economic justification from a safety standpoint of our substation designs. Because of the lack of safety rules such as we have for line construction and because of the varying conditions to be met, the practices of the operating companies are quite different. These practices and the supporting arguments are presented. The study has been limited to three major subjects as stated in the following outline of the report:

Introduction.

Temporary Protective Grounding.

Barriers and Other Methods of Preventing Contact With High-Voltage Equipment.

Interlocking or Safety Locking of Switching Equipment.

Conclusions.

SUPPLEMENTARY PAPERS

Temporary Grounding as Applied to San Joaquin Light and Power Corporation System.

Ground Cable Reel and Rod for Temporary Grounding.

Interlocking of Disconnect Switches and Oil Circuit breakers.

IN recent years much emphasis has been given to the subject of safety design. It therefore seems appropriate that a subcommitteee should be organized to make a study of the designing of distribution substation apparatus that will minimize the possibility of damage to persons and property. In addition to the natural desire to protect human life, we are eager to reduce the cost of accidents to electrical utilities. When we are told that the companies are paying $20 an employee, or $6,000,000, annually for accidents,

* Report of subcommittee on preventive engineering, electrical apparatus committee, Engineering Section. C. N. Parker, chairman. C. D. Bidwell, A. S. Glasgow, D. Hall, R. B. Kellogg, E. W. Otto, J. C. Porter, R. R. Richey, H. L. Sampson, H. C. Stanley.

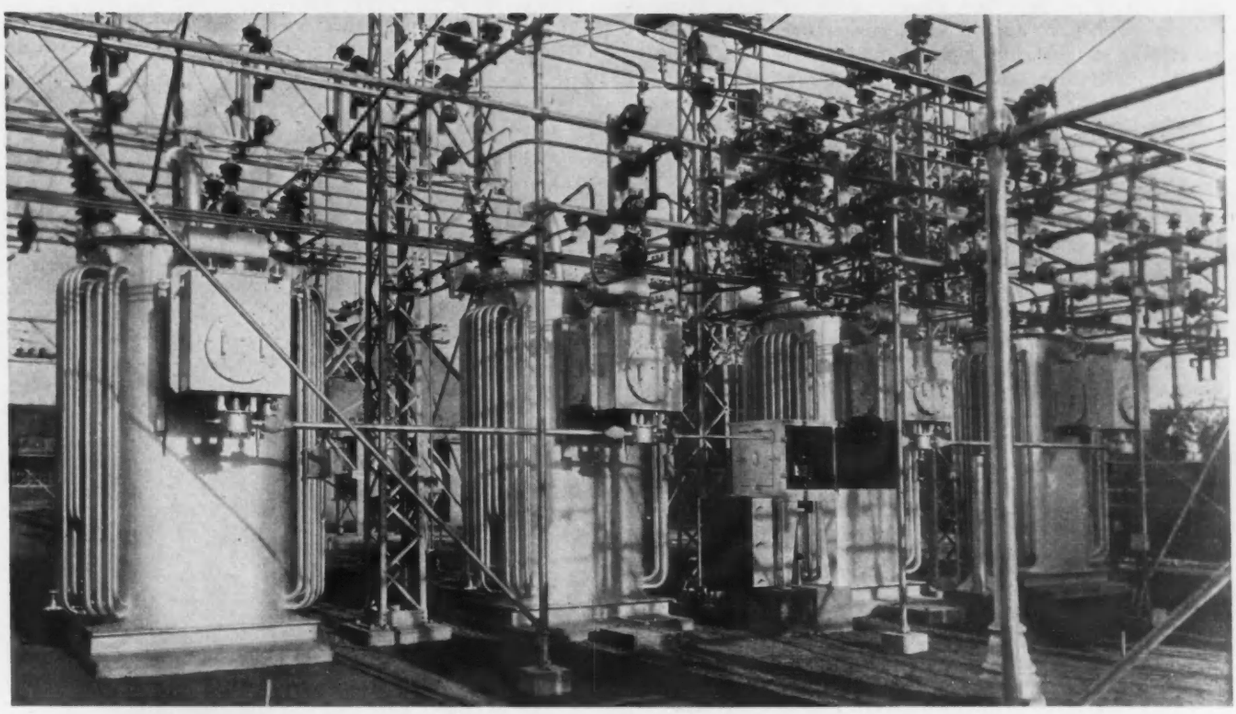

Fig. 17—Latest design of group-drive automatic tap-changing equipment installed on a transformer bank at a Pacific Gas and Electric Co. substation

we realize the importance of this effort and the justification for expenditures to prevent such accidents.

There are two extremes in safety design— one being to depend entirely on human intelligence, instinct, and training, the other, to provide interlocks, barriers, and mechanical protection to such an extent that man is relieved of all personal responsibility. Statistics show that complete reliance cannot be placed on the training of men, nor is it economically practical to relieve men of all personal responsibility, even if such a thing were possible. We must, therefore, find a safe middle course. The fact that no system is foolproof under all conditions should not be an indictment of the system. "If it merely deters without absolutely preventing access to ungrounded equipment, it may prevent many accidents."

The attitude of one of the committee members toward this subject is stated as follows:

> The general trend of our studies this year is to follow the line of "economic justification of designs." When this is applied to the question of safety design, we find ourselves in the midst of an argument almost immediately, because no money value for a human life can be agreed upon. It appears to me that the answer to these arguments should be that we are justified in anything that is a real safety measure, where such measures are needed. To determine where there is such need, it seems to me that we shall have to decide just what kind of a man we are trying to protect.
>
> The idea of making anything foolproof is all right if we remember that there are many kinds and grades of fools and do not try to protect all of them. It is questionable whether it is possible at any cost to protect some of them. I believe that we should consider the average station operator and maintenance man as one who has average intelligence and is subject to ordinary thoughtless acts, and we should so design our stations that such a man can work in safety.

The work of the committee during the past year has been centered on the following three major subjects:

1. Temporary protective grounding.
2. Barriers and other methods used to prevent accidental contact with high-voltage equipment.
3. Safety interlocking.

We have attempted to stress the reasons, results, and practices of the operating companies. The practices of the five operating companies who have submitted information are quite divergent. This is largely due to the differences in operating conditions which must be met and also to the fact that we have no standardized rules for substation design such as we have in the construction of lines. It therefore seems best to quote from their reports and also to include four supplementary papers which have been prepared for the committee and leave the reader to draw his own conclusions.

Temporary Protective Grounding

Summary—

A majority of the companies are providing gang-operated grounding switches, while only one company makes a general use of single-pole switches for this purpose at distribution substations. Two companies do not provide grounding switches for lines of less than 70 kv., except at generating stations, and another company is considering the same plan. Ground chains have been abandoned and copper cables substituted. In most cases these cables are used to ground buses and equipment as well as lines, but one company makes a general use of bus-grounding switches. The arguments in favor of these plans are stated in the following discussions.

Los Angeles Gas and Electric Corporation—

We do not use single-pole grounding switches; we use cables and clamps for grounding 4-kv. lines and buses and other apparatus not provided with grounding switches. We do not favor the use of ground chains, as they do not make good contact with the bus and under a short circuit will burn off, and we have found them unreliable. We use gang-operated grounding switches entirely for 16.5-kv. lines and above. We feel that it is the safest practice, as all three phases are grounded at the same time, and in case the grounding switches are closed on an energized bus, no flash or injury to the operator would be sustained. We believe that the extra expense of using gang-operated ground switches over single-pole switches or chains and cables is more than warranted, for with the gang-operated switches an interlocking system can be used that will prevent the closing of ground switches on energized lines or buses.

We think ground switches have a decided advantage over ground chains or cables that would more than warrant the extra expense involved. We have had several accidents due to the use of ground chains; one of these accidents caused the death of the man using the chain. In another accident, where no one was injured, considerable property damage to the substation was caused, together with an outage of 14 minutes. This accident was caused by energizing the bus when it was grounded with a chain. The chain was burned up, and the short circuit spread between the buses and all over the cell structure, even burning the wire-glass windows in the building. It was only by a narrow margin that several employees were not injured. In this case, if the bus had been grounded with gang-operated ground switches, there would have been no flash and much less property damage. It can readily be noted from the above two accidents that ground switches have a decided advantage over chains or cables, and from our experience the extra expense is justified.

San Joaquin Light and Power Corporation—

Gang-operated grounding switches are used on all 110-kv. and 70-kv. lines. The safety, the convenience, the fact that all the phases are grounded simultaneously and the frequent occasions when a line must be grounded, warrant the extra cost. Distribution lines, when they are taken out for work on them, are not ordinarily grounded at the station, and no ground switches are provided on them. Both distribution and transmission lines are grounded at the point where the work is being done. When it is necessary to ground the high-tension bus or any of the 11-kv. distribution lines or bus work, ground cables are attached by clamps on insulated handles. The number of times this is necessary hardly warrants the cost of installing ground switches.

Southern California Edison Company Ltd.—

We use single-pole switches almost exclusively for the grounding of lines. Gang-operated grounding switches are

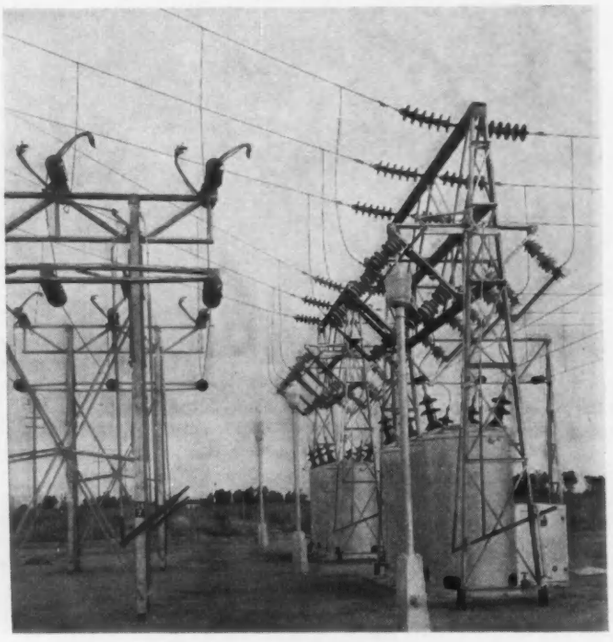

Fig. 1—Method of installing grounding switch on 70-kv. structure at Camden substation, San Joaquin Light & Power Corporation

used where the location is such that stick-operated switches would not be satisfactory. Elevation, or location within inclosures, sometimes necessitates remote control, and then the gang-operated type is used. The expense is then justified by necessity.

We do not make a general practice of grounding buses and apparatus to work on them. A few stations have been equipped with bus-grounding switches, but with open outdoor construction, where everything is in sight, it is not considered necessary to provide them, except above 66 kv. A few maintenance men who prefer to ground such equipment use flexible cable and clamps.

We do not consider chains as a safe ground connection because of their very limited carrying capacity. Our linemen use cables and clamps. Up to this time we have always provided grounding switches in our stations for use on lines out for work, but we are now seriously considering the plan of omitting them on future jobs. The linemen cannot depend on them and have to put on their own grounds.

San Diego Consolidated Gas and Electric Company—

It is our practice to use gang-operated ground switches on 66-kv. stations only, and in such cases these ground switches are used to ground the transmission line entering the station. I do not know of a cheaper method of grounding a transmission line at the station, since the ground blades are simply tied to the steel structure, and the single-operating handle closes the three blades to the line terminal after the other disconnects are open. It is our opinion that the ground switches which we employ well justify their expense, because a ground chain, which is a cheap device, will not afford sufficient protection, and a cable arrangement is somewhat clumsy when used on a transmission line and is very dangerous to install and remove. We do not use single-pole grounding switches.

The grounding of buses and apparatus in and about substations is accomplished with the use of flexible cable or well made grounding clamps, the cable being of sufficient size to be fairly sure that it will not blow up in case of accidental connection to live circuits when the bus is supposed to be dead. So far we have not had test cases and might say for this we are thankful.

The Southern Sierras Power Company—

In all recent construction we have provided ground switches on voltages of 88,000 and above. These are gang-operated switches in all cases. In some of the older construction, single-pole switches were used for grounding high-voltage lines. We have provided no bus-grounding switches, but make use of ground cables along with clamps in some cases. We have felt that, since it is necessary to ground the line on each side of the workman and within his view, grounding switches for 33-kv. and lower voltage lines at substations, except where generating capacity is available, are unnecessary. All construction crews and substations are equipped with flexible ground cables. We have found the use of these cables quite satisfactory, as we have had no accidents to employees where they are used. In one case a line was burned down when, through a misunderstanding of orders, a ground cable was pulled over an energized line, but there was no damage other than the burning of the conductor.

Methods Used to Prevent Accidental Contact With High-Voltage Equipment Such as Barriers, Metal Inclosures and Elevations

Summary—

The type of design used and the location of the substation to a large extent fix the class of protection used. In indoor construction the use of concrete cells, metal inclosures and screen is common. In outdoor construction the elevation and spacing of live parts usually provide sufficient clearance from workman for safety. Where there is still danger, the use of screens is most common. The present tendency seems to be toward metal rather than concrete cells. Steel cells are used also for low-voltage outdoor construction.

Los Angeles Gas and Electric Corporation—

We inclose all voltage regulators, potential transformers, power transformers, and oil circuit breakers in separate rooms or cells, and make this procedure common practice.

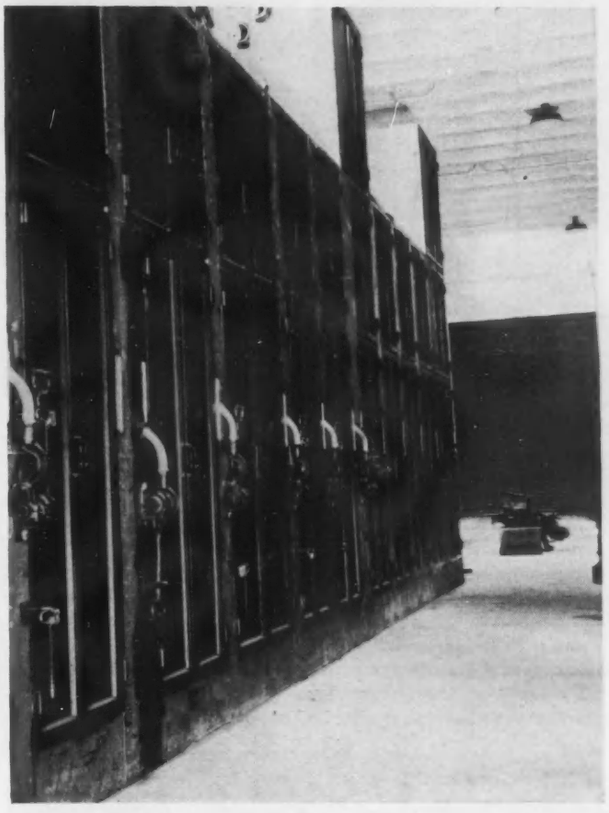

Fig 2.—Oil circuit breaker cells, Los Angeles Gas and Electric Corporation

All 4-kv. buses and disconnect switches are inclosed in concrete or steel compartments. We do not inclose 33-kv. buses and disconnect switches in compartments, except in our important downtown substations and switching stations, where short-circuit values are high. We isolate all 33-kv. buses, disconnect switches, and incoming line entrance bushings in our urban substations by elevating live parts beyond the reach of workmen.

Wire screens are used to divide the space over each 33-kv. oil circuit breaker cell so that in case one cell is out of service, workmen cannot walk across the top into adjacent live switches. We had one accident in which the operator was killed due to this condition, whereas a wire screen dividing the space over the cells would have prevented it. We think that the expense of installing screens of this type is fully justified. We also inclose lightning arrester equipment located on the roof of substations with fences. Each line has an individual screened compartment, with an inspection door which is kept locked. The disconnect switches are gang-operated and can be controlled from outside the inclosure. Wire screens are also placed between the 33-kv. buses over two transformer banks. In cleaning insulators with one bank of transformers out of service, this screen prevents men from crossing over into the space occupied by the live bus.

San Joaquin Light and Power Corporation—

As all our distribution stations are outdoor type, we have adopted the method of elevating the live parts to prevent accidental contact with them, as being the simplest and most economical. A certain amount of height must be attained over roads, etc. to conform to G.O. 64-A, and this is usually ample to secure good elevation of bus work and equipment

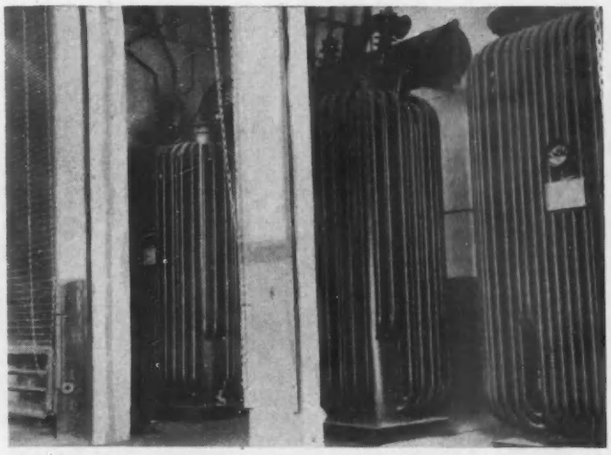

Fig. 3—Power transformer cell, Los Angeles Gas and Electric Corporation

without any additional cost. Occasionally it is not desirable to elevate some of the 11-kv. equipment, such as large station service transformers, and in such cases they are set on the ground with screens placed around them. Barriers are placed above the 11-kv. circuit breakers and between adjacent feeders to prevent men working on a switch from coming in contact with live parts. In high-tension designs, clearances are sufficient so that no barriers are required, and all equipment and bus work are elevated sufficiently to prevent any accidental contact with live parts.

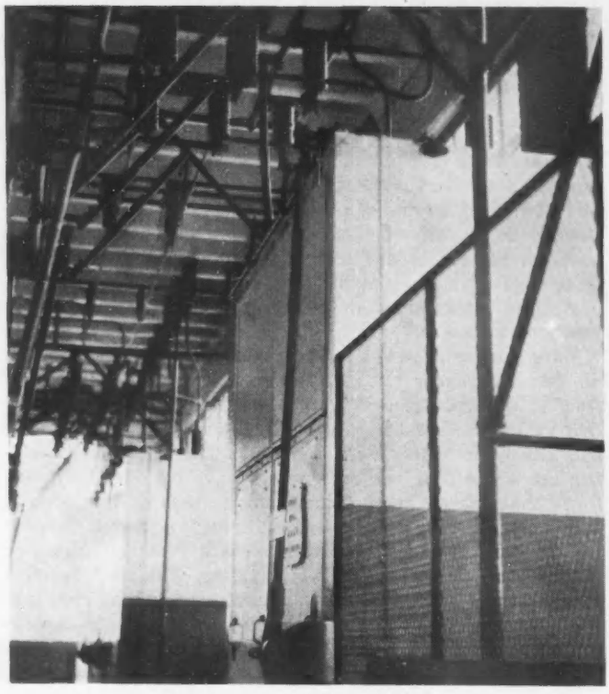

Fig. 4—Voltage transformer cell, with grounding switch above and electrically interlocked handle, Los Angeles Gas and Electric Corporation

In making studies for designs of our stations, we endeavor to arrive at a balance between safety, accessibility for maintenance, economy, and ease in making future additions.

Southern California Edison Company, Ltd.—

As our design practice is almost exclusively connected with outdoor construction, we are limited to screens and isolation by elevation for protection against accidental con-

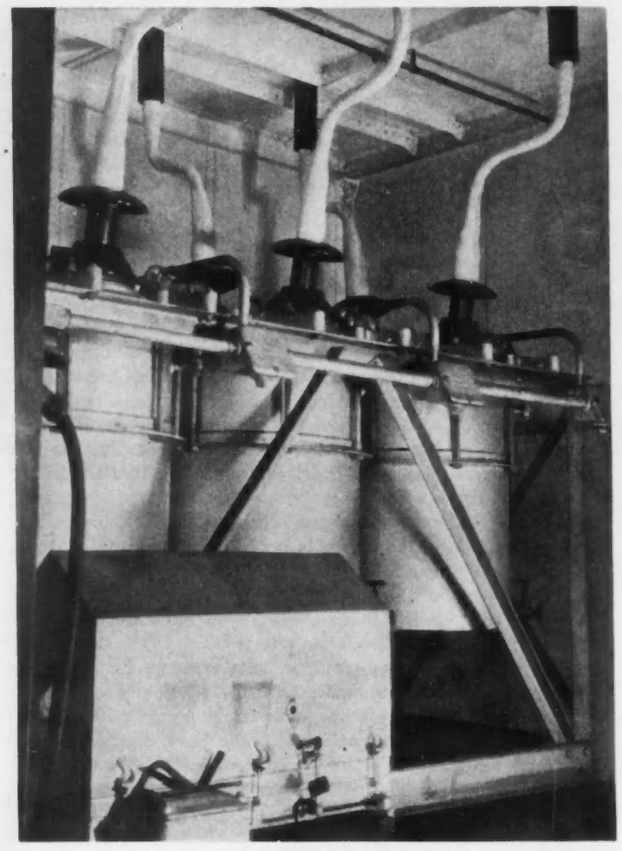

Fig. 5—Steel oil circuit breaker cell, Los Angeles Gas and Electric Corporation

tacts. The same practice applies to any voltage from 4 kv. up.

The use of screens and barriers should be governed by the same principles as the use of interlocks, i.e., to protect

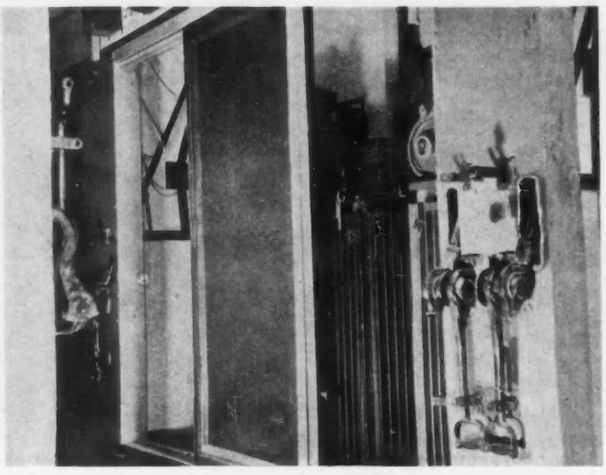

Fig. 6—Voltage-regulator cells and electrically interlocked switch handles, Los Angeles Gas and Electric Corporation

the average man—and no attempt should be made to get full 100 per cent protection. In fact, it is not possible to reach that limit. Again, there is a very good argument that too many barriers are objectionable because they create hazards in their removal for work and because they have a tendency to create a sense of false security and to make men more careless.

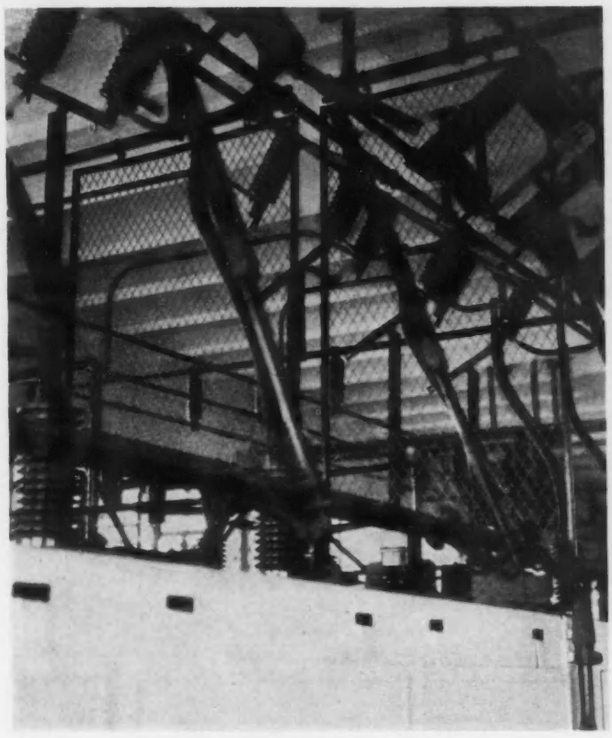

Fig. 7—Screens dividing space over 33-kv. breaker cells, Los Angeles Gas and Electric Corporation

San Diego Consolidated Gas and Electric Company—

In our main generating station, disconnecting switches, oil circuit breakers, potential transformer compartments, etc. are in locked rooms, accessible only to experienced operators who must apply for a key and be furnished with written instructures as to what devices to operate. 4-kv. substation switchboards recently installed are all metal-inclosed cubicles, so that no exposed live parts are possible. This refers of course to indoor substation equipment. We have not so far installed a metal-inclosed outdoor cubicle, but one such station is under consideration. Balconies, galleries, and platforms are employed in 12-kv. and 66-kv. transmission work.

Practically all 66-kv. substations are outdoor, where we make use of delta-star or similar standard equipment, isolation being accomplished by elevation. We make extensive use of barriers or screens, particularly in 12-kv. systems.

The Southern Sierras Power Company—

As most of our substations are located out of doors, we have provided for safety by elevating the energized equipment. We have made frequent use of screens between buses to permit workmen to work safely on one bus while the adjacent conductors are energized. At the Hoover Dam substation we placed a screen over the low-voltage bus to prevent a person working on the roof of the substation building from contacting it, also to prevent falling articles from "shorting" the bus. In a number of cases we have used metal switch houses to inclose low-voltage equipment in our outdoor substations, while in other cases we have elevated similar equipment. A decision as to which method to use depends upon the cost. In a few indoor stations we have used concrete cells to isolate both buses and switches.

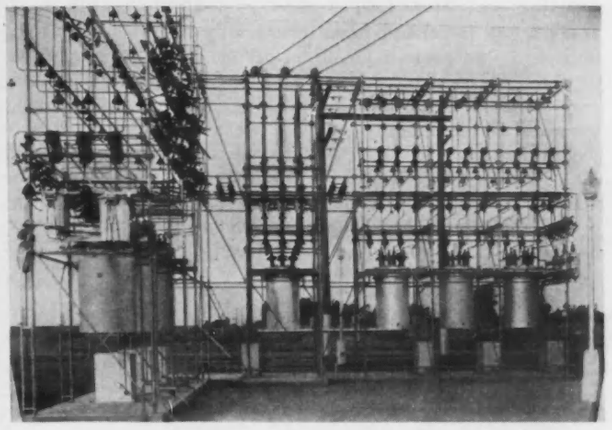

Fig. 9—11-kv. structure showing barriers between and above switches, Camden substation, San Joaquin Light & Power Corporation

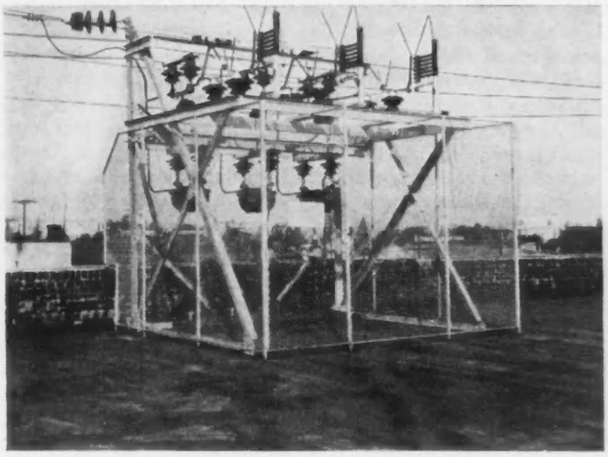

Fig. 8—Screens used to prevent contact with lightning arrester equipment, Los Angeles Gas and Electric Corporation

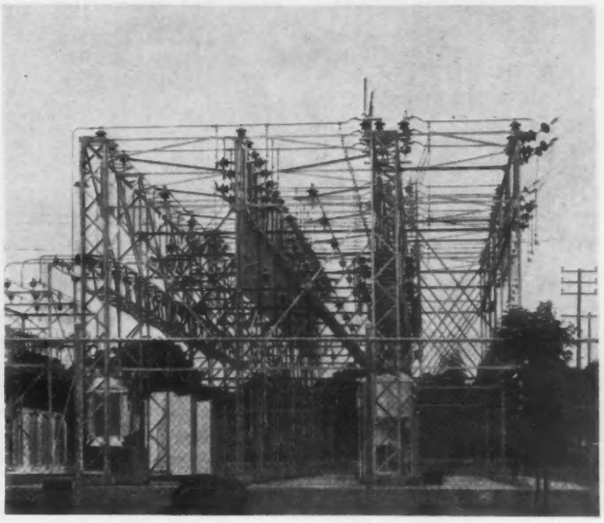

Fig. 10—View of Elsinore substation showing screen between buses, The Southern Sierras Power Company

Interlocking or Safety Locking of Switching Equipment

Summary—

The general practice in the use of interlocks is to install them on oil circuit breakers and gang-operated switches located indoors where space is limited and where barriers, cells, etc. make it difficult to see the position of all the equipment involved. They are also installed out of doors where it is necessary to concentrate a large number of switches into a limited area or where special hazards are involved. Since many of the substations in California are located out of doors where the space is not an important factor, the use of interlocks is rather limited with some of the companies.

Los Angeles Gas and Electric Corporation—

We apply interlocks to all electrically operated oil circuit breakers. We also employ interlocking to all gang-operated bus-sectionalizing disconnects and to gang-operated grounding switches. In the interlocking of bus-sectionalizing switches and grounding switches we use an electrically released handle. In the case of bus-sectionalizing switches all disconnecting switches tied to the bus must be opened before the electrically released handle can be operated. In other words, the bus-sectionalizing switch cannot be opened until the bus has been freed of all electrical connections, thus insuring that there is no current flowing in the sectionalizing switches. The bus-grounding switches are also operated with an electrically released handle, which requires that all disconnect switches connected to the bus must be opened before the handle will release and allow the grounding switch to be closed. In stations where we have potential transformers connected to the bus, we also introduce a voltage relay that must drop out before the grounding switch handle will release, thus giving a further check in de-energizing the bus before grounding. We also use the same method in grounding 33-kv. lines, both overhead and underground. The above application of interlocks to bus-sectionalizing switches and grounding switches applies only to 16.5-kv. and 33-kv. buses and lines, as we do not install bus-grounding switches on 4-kv. and lower-voltage buses.

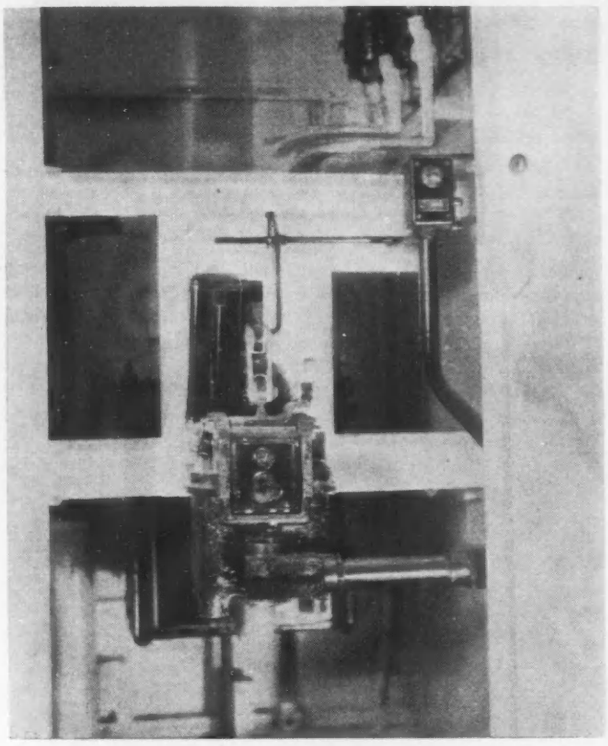

Fig. 11—Interlock mounted in switch cell, Los Angeles Gas and Electric Corporation

It is the practice of this company to equip electrically operated oil circuit breakers with a mechanical interlock, which releases a key when the oil circuit breaker is opened. The removal of this key opens the closing control circuit of the breaker, thus preventing the reclosure of the breaker until the key is returned. The released key may be used to unlock the padlock on the operating handle of the corresponding gang-operated disconnect switch. This interlock prevents the opening of the disconnect switch under load or the opening of the wrong disconnect switch. The lock on the interlock projects through the face of the door, so that the key can be removed after the breaker has been opened without opening the door of the cell.

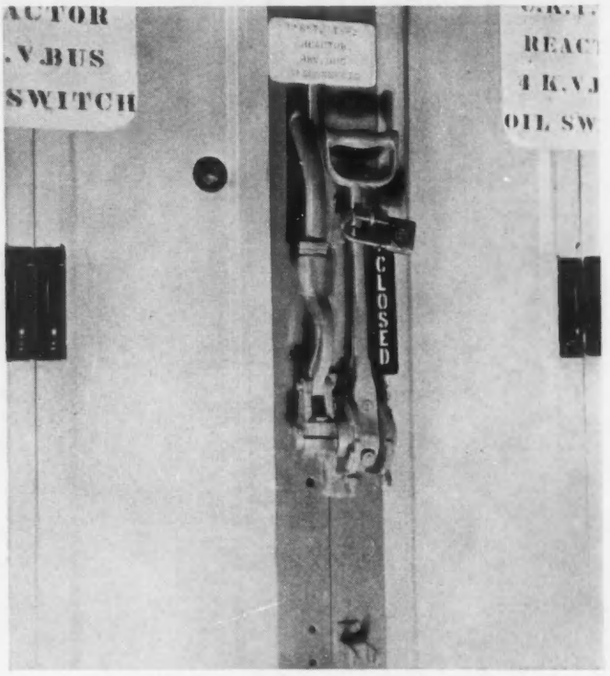

Fig. 12—Interlock on switch handle, Los Angeles Gas and Electric Corporation

We adopted the practice of installing interlocks to prevent the opening of disconnect switches under load and thus to avoid serious damage to property, and a resulting outage to the station involved. The use of interlocked disconnect and ground switches would probably have prevented the six accidents that occurred in the five years previous to the installation of the interlocking systems. These accidents were all due to opening disconnecting switches under load, and they caused outages of from five to thirty minutes in the stations where they occurred. Reducing these accidents to a money basis, they would represent a considerable loss of revenue to the company and damage to property; also in two of these accidents serious injury resulted to the operators.

Outages of this nature often represent considerable loss and inconvenience to the customer and injury to the company's reputation for giving good service. Also, where competition is severe, outages of this kind interfere with obtaining new business. Since we have installed interlocks we have had only one accident due to opening of disconnects under load; we therefore believe from our experience that the added expense of installing an interlocking system affords enough protection against property damage, injury to

operators, and outages to justify their use. We have had no cases yet where our operating experience would indicate that the interlocks installed were not satisfactory or not economically justified when used properly.

San Joaquin Light and Power Corporation—

Interlocking of oil circuit breakers of distribution stations with disconnects and grounding switches is not practiced by this company. Neither are interlocks provided between disconnects and ground switches. In such instances where it is essential that circuit breakers operate in a certain sequence, such as in starting condensers or in changing taps on manually operated tap changers, interlocks in the control wiring or other mechanical means are used.

One reason for the absence of any interlocks between the oil circuit breaker and its disconnects or the disconnects and ground switch is that stick-operated disconnects are used both on transmission and distribution switches. These are not readily interlocked, but are being used because they fit into our type of construction, have a good record both from service and accident standpoints, and are much cheaper than gang-operated switches. Because their method of operation is so different, there is perhaps less need of interlocks between disconnects and ground switches when the former are stick-operated and the latter gang-operated, which is the manner in which this company installs them, than when both disconnects and ground switches are gang-operated. In the latter case, the operator is confronted with two or three handles that perhaps look somewhat alike, and even though they be labeled, there is some chance of his taking hold of the wrong one.

No serious accidents have occurred from lack of interlocks, although there have been one or two system disturbances caused by the operator's closing the ground switch on the wrong line, which would have been prevented by interlocking the ground switch with the disconnect switches. Our company has had no experience with interlocks on circuit breakers of distribution substations. While it would appear that a simple and rugged interlock scheme that could be installed at small expense would have some merit, there is doubt whether expensive and elaborate devices justify their cost.

Southern California Edison Company Ltd.—

This company does not make a regular practice of using safety interlocks of any kind. A few have been installed between disconnect switches and ground switches, generally because the manufacturer furnished them that way. The fact that nearly all our stations are built with outdoor equipment so that everything is in plain sight makes interlocks unnecessary in our opinion. We have had no serious accidents which would have been prevented by interlocks. A few hot disconnects have been opened, but with outdoor construction these cannot be classed as serious accidents.

Our system of training operators has been so satisfactory that we believe our position is justified. Last year, with 2,450 oil circuit breakers in service in distribution stations and with most of our disconnects single-pole, stick-operated, we had 532,000 operations with only 23 mistakes, one of which was the opening of a hot disconnect. This includes all kinds of errors, such as dropping the wrong circuit, dispatching mistakes, etc. Also, the percentage of mistakes has steadily improved over the last eight years since records have been kept. It is quite evident that if this record can be kept up, we could not justify the cost of any elaborate interlock system.

San Diego Consolidated Gas and Electric Company—

We have no interlocking for safety purposes other than where electrical interlocks are used so that only one of two breakers may be closed. Where breakers are required to be rendered inoperative, we use either a padlock or we remove the operating circuit and employ a tag on the switchboard.

The Southern Sierras Power Company—

We have used interlocks only to a limited extent on our distribution substations. On our more recently constructed substations we have installed interlocks between the gang-operated bypass switches and oil circuit breakers for 88-kv. and higher-voltage lines. Wherever differential protection has been provided for condenser equipment, we have also installed interlocks. At the San Bernardino substation interlocks are installed on all indoor gang-operated switches and oil circut breakers connected to the 6.6-kv. buses. A few interlocks have been provided to give protection where special equipment has been installed, such as on bus tie switches, where it is important to have only one switch closed at a time.

Platforms for Operating Outdoor Disconnecting and Grounding Switches

The general practice of the California companies is to install a well grounded copper network under each substation and to ground the handles of the switches; only in cases where there is a question about the ground connection are insulated platforms used. One company requires the operators to use rubber gloves in handling switch operating handles.

Conclusion

While the foregoing report does not attempt to present any conclusions, it is believed that the information given will be an aid to the designing engineers in determining the safety measures necessary for their particular construction. It is apparent that each design will require individual study to determine when the proper degree of safety has been reached. We believe that the four appended papers will present in more detail the practices of some of the companies on the subjects under discussion.

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*Safety Design Practices of Pacific Gas and Electric Company**

Temporary Protective Grounding

THIS company has made a practice of grounding all apparatus before working on same, either for construction purposes or for routine maintenance.

Even though there is a delay and the attachment of these ground clamps sometimes works a hardship on the men, the company, and particularly the safety committee, feel that solid grounding is necessary. The rules in this regard are very strict.

We insist that all apparatus shall be grounded on the bus side and also on the line side.

We have a standard knob which is attached to the ground bus in stations and substations, the grounding clamps and flexible conductors being attached at convenient points to these knobs.

In some of the later stations disconnects are installed which have two jaws, one for the line and one for the ground connection. Ground connection is accomplished by pulling the blade and moving it sideways through 45 deg. to engage the ground jaw. These have proved very satisfactory.

Lately some attempt has been made to procure a satisfactory indicating device which will tell whether the bus or circuit is energized or not before the grounding devices have been attached.

The progress in this respect is slow, due to the possible danger of a false indication.

These remarks apply principally to major stations and substations. In the outlying country stations, the line is closed

* Submitted after presentation of subcommittee report.

through a test fuse before the grounding devices are attached.

Guards, Barriers, Cells, Etc.

As regards barriers, this company has always placed barriers at all points where the clearance is small and also there has been a tendency to install barriers which serve as a guide to the operator rather than as an actual protection in case of a fault.

One step which this company is taking which we believe will eliminate much of the hazard which exists due to faults and incorrect operation, is the use of steel cells and steel doors. Much experimenting has been done, and all new work within the last two years has employed the use of steel entirely. Experimental doors are now being built which will easily and with minimum expense fit the present older type of cells which have wood and transite doors. These steel doors have a locking bar which can be padlocked or interlocked with the O.C.B. if desirable, so that the doors cannot be opened if the O.C.B. is closed. Also the operator can only open the doors for one particular cell and not the doors of any adjacent cell which may contain energized apparatus.

We believe that there is a high degree of safety attainable with the use of steel. It is heavily grounded and, in case of an arc, the amount of gas generated is at a minimum, due to the low resistance path to ground and the consequent faster trip speed of the relays. Experience has shown that, with the steel doors, the amount of property damage and danger to human life due to a fault have been substantially reduced.

Where higher currents are encountered, producing strong magnetic fields, aluminum has been used instead of steel. Aluminum under test has proved as strong as steel and the cost per set of doors compares very favorably. The above would apply to large generator or reactor cells.

Operation indicators are installed on practically all structures of 11-kv. and above, which are connected mechanically to the O.C.B. and give a direct indication to the operator whether the switch is open or closed.

Safety Interlocking

At Station "A," the new steam plant, the disconnects are interlocked mechanically to the O.C.B. mechanism so that they cannot be opened unless the O.C.B. is open. They are also gang-operated, but in the substations very few gang-operated disks are used.

This company has quite a bit of elevating and truck-type switching apparatus and, of course, in these cases an interlock is furnished by the manufacturer so that the O.B.C. cannot be removed unless it is in the open position. This is one reason why we prefer the metalclad equipment, because disconnects are eliminated and, therefore, the hazard connected with their operation.

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*Temporary Grounding as Applied to the San Joaquin Light and Power Corporation System**

TEMPORARY grounding for the protection of employees as used in connection with substation design, construction and maintenance may be classed under two heads:

1. Permanent or fixed equipment.
2. Portable equipment.

Permanent or fixed grounding equipment is that used for grounding our 70-kv. and 120-kv. transmission lines on the oil-switch structures on which the lines terminate. Each transmission line, when taken out of service for work, is grounded at each end by closing a gang-operated three-pole grounding switch by means of a handle operated from the base of the tower. The ground blade consists of a moving blade so located on the disconnect switch base between the post insulators that it gives ample clearance when open, but to close, is rotated until contact is made in a jaw supported by the disconnect switch insulator on the line side. The ground switch thus requires no tower space or insulators other than what is required by the disconnect switches.

The disconnects are stick-operated and no interlock is used between them and the ground switch. No doubt this may be the cause for some difference of opinion, but operating experience over a number of years has not demonstrated that the present simple equipment should be supplanted by more expensive and interlocked devices. It is true that occasionally a hot line has been grounded through the lapse of memory of an operator, but these cases are so few and far between as to be classed as very exceptional.

No permanent equipment for grounding distribution circuits is installed in the substation, nor are distribution lines ordinarily grounded anywhere but at the location of the work. The reason for this is that most distribution circuits are not killed in their entirety but sections are taken out of service for work, with the rest remaining in service from the nearest substation. In an area with more or less of a network this might mean service from the same substation or, in the case of a tie-line between two substations, service might be from both substations. Thus, when a section of line is out of service in a network or between substations, local or field grounding must be relied upon for protection, as no substation grounding would be possible. It has therefore been the belief that this field grounding should be the sole grounding applied, even if a section of the line were out directly from the substation bus, as this system makes the foreman of the line crew directly responsible at all times for the condition of the protective grounds.

The use of hot-tap tools has also reduced the former frequency with which lines were placed out of service directly from the substation bus, with a consequent reduction of the need for grounding of any sort.

Portable equipment for grounding at substations consists of the company standard grounding device for lines, and is used by maintenance and construction crews for the purpose of protection when working on sections of buses, oil circuit breakers and similar apparatus.

The device consists of a spring pressure jaw with copper-lined contact faces, mounted at the end of a 6-ft. treated stick for handling, to which is attached a length of No. 2 rubber-covered flexible copper cable. Three of these jaws and cables are joined together to a suitable length of No. 2 copper cable, to the end of which is attached a grounding clamp. The latter is of bronze and of such size as to permit its being clamped around ground wires, tower legs or to 2-in. or smaller ground pipes. This device thus is used to short circuit and ground a line or group of busbars. The ground clamp is, of course, applied first to the nearest available station ground and then the ground hooks are applied by means of their insulated handles. Two sets of these devices are used, in accordance with the company rules.

Substation maintenance and construction crews carry two sets of this equipment as part of their tools in addition to the sets located at each substation.

* Prepared by C. E. Schnell.

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*Ground Cable Reel and Rod for Temporary Line Grounding—The Southern Sierras Power Company**

THE Southern Sierras Power Co., at the beginning of its operations, provided linemen with steel sash chain for the purpose of grounding high-tension lines while work was being done upon them. The usual difficulties were encountered in handling this chain, and on account of rusting and

* Prepared by E. Y. Porter.

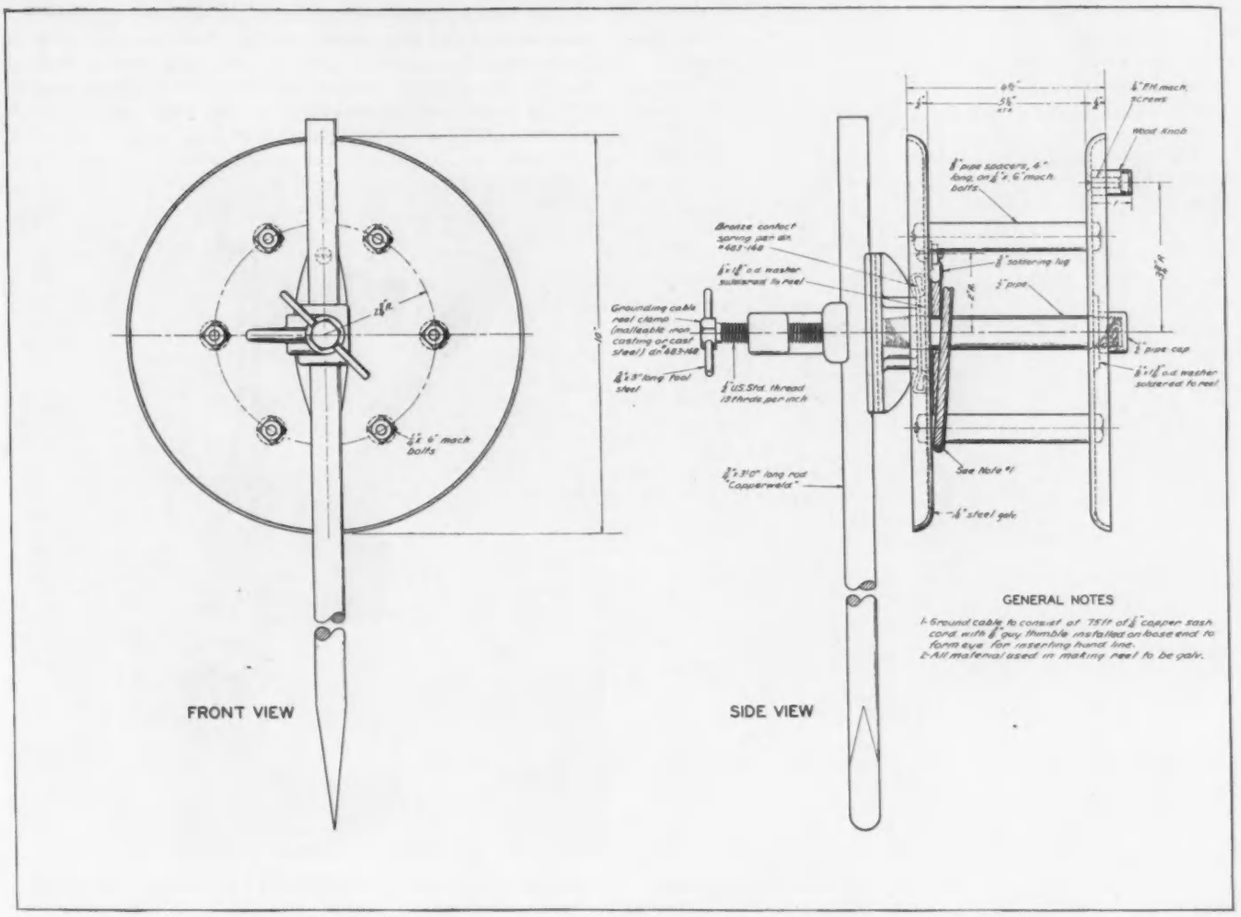
FRONT VIEW
SIDE VIEW
GENERAL NOTES
1-Ground cable to consist of 75 ft. of ¼" copper sash cord with ⅜" guy thimble installed on loose end to form eye for inserting hand line.
2-All material used in making reel to be galv.

Fig. 13—Assembly of grounding cable reel used by The Southern Sierras Power Company

poor contact at each link, it was found unsatisfactory and not entirely safe. We therefore abandoned the chains in favor of the use of ¼-in. copper sash cord. The difficulty in the use of this copper cable was found to be in the manner of handling it and keeping it free from kinks and entanglements. We therefore provided reels which, at first, were made of wood. After the cable was unreeled, one end was attached to a piece of anchor rod which was driven into the ground and the other end was attached to a hand line which was thrown over the line to be grounded, and the cable drawn over and tied taut. The reel idea proved a great help in keeping the cable in condition, details of the reel construction being gradually improved until the all-metal reel shown in Fig. 13 has been evolved.

One of the chief features of this reel is a malleable iron screw clamp, to which the spindle of the reel is rigidly attached and which can be used for clamping the reel rigidly to a driven rod or to almost any part of a steel tower. The illustration indicates clearly the various parts. In using this reel for grounding high tension lines, a ¾-in. copperweld rod is first driven into the ground which, when the reel is clamped to it, becomes a satisfactory holder for the reel, used either as a pay-out or take-up device. It will be noted that the ground end of the grounding cable is securely attached electrically and mechanically to the frame of the reel; also that sliding electrical contact is provided between the reel proper and the clamp. This obviates any possibility of poor electrical connection between the cable and the ground rod or tower member.

It is obvious that cable may be used as a throw-over grounding device as described above or may be connected to any kind of suitable clips or other means for connecting it to the lines or other equipment which it is desired to temporarily connect to ground.

We have found this equipment highly satisfactory for use on both distribution and transmission line construction and repair work. Our rules require that high-tension lines should be grounded on each side of the point at which work is being done, in addition to and independent of any special grounding which may be provided at the substation.

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*Interlocking of Disconnect Switches and Oil Circuit Breakers—Los Angeles Gas and Electric Corporation**

THE territory served by the Los Angeles Gas and Electric Corp. is of an urban character. The congested condition of the city makes land values high and, as a result, the ground space that can economically be devoted to distribution substations is necessarily limited. The limited space available for the substation requires the use of an indoor type. The restricted space available inside the building, together with the need of a greater fire protection and protection against accidental contact with energized parts, has made necessary the inclosing of oil circuit breakers, transformers, regulators and the like in cells or compartments.

The need for interlocking the oil circuit breakers and disconnects has become greater as the apparatus has been confined. Many of the disconnect switches are gang-operated

* Prepared by F. H. Streit.

and, due to the cell construction, located in positions that are not readily seen by the person operating. The cell construction has also made the tracing of the circuit connections more difficult for the operating personnel and as a result the checking of switching operations by actual sight of connections has been entirely eliminated.

The policy of interlocking the disconnect switches and oil circuit breakers and also all bus and ground switches has been adopted by the Los Angeles Gas and Electric Corp. The system used in the substations is that of interlocking the disconnects against the breakers by the use of padlocks, the keys of which are controlled by the oil circuit breakers. A somewhat more extensive system of interlocking oil circuit breakers and disconnects has been installed at the Alameda St. station on the 33-kv. section. The interlock system used at this station is entirely mechanical and is of the key transfer type. All disconnects are gang-operated and the operating handles have the interlocks attached to the handle shaft.

The 33-kv. bus in the Alameda station is located on two floors, with bus disconnects between the floor sections. Fig. 14 show a single-line diagram of the 33-kv. section. The

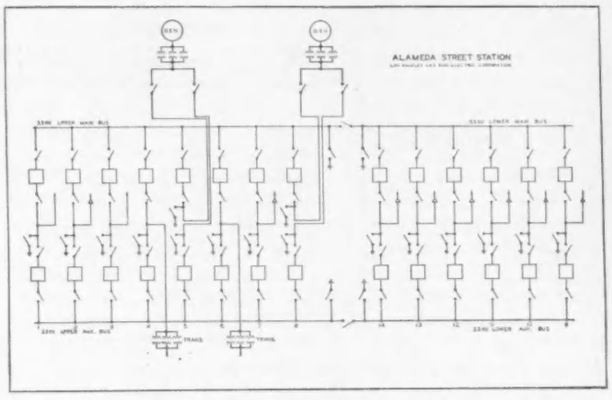

Fig. 14—Single-line diagram, Alameda Street Station, Los Angeles Gas and Electric Corporation

oil circuit breakers are located in cells with their respective disconnects, which are six-pole, single-throw, gang-operated from a single operating handle located outside the respective cell. Fig. 15 shows a typical operating handle and interlock. The photograph was taken during construction and does not show the doors that will be mounted on the front of the cell, leaving only the operating handle and interlock in view. The bus disconnects and bus section ground switches are located in cells separate entirely from the oil circuit breaker cells. Because of the complexity of the connections between the upper and lower buses, it was necessary to locate the bus disconnect cell in a position that is not readily observable from the floor. The disconnect is gang-operated and the operating handle, together with the operating handles for the bus section grounds is located on the lower floor.

In view of the conditions as they exist at the Alameda station, it was felt that a somewhat more extensive interlocking system was justified. The interlocking system installed is of the definite sequence type. This type allows the reverse of any given switching operation to be done only in the reverse sequence to which the original switching operation was set up and the original is set up only in a manner predetermined by the interlock system.

Several objections have been raised to the interlocking system, one being that it slows up the switching operations. The gang-operating of the disconnect switches has materially speeded up the switching operations over that of the hook-stick-operated single-pole single-throw disconnects. In the checking of line or bus before the application of grounds, the key interlock system has materially speeded up the operation in that the key or keys are a check on the circuit at all times. The increased speed is especially true in stations such as the Alameda station where the bus sections are on different floors of the building or are widely separated so that a visual check is not readily made.

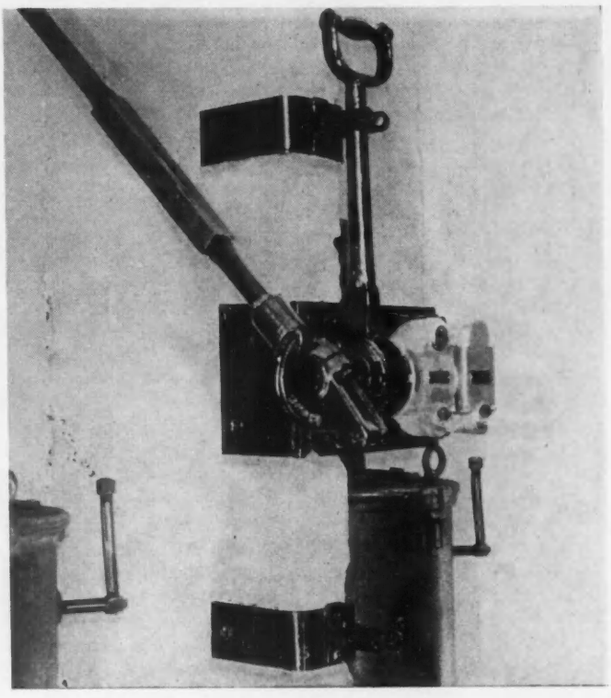

Fig. 15—Application of interlock to switch operating handle

It was possible to use the same type of handle-interlock as shown in Fig. 15, on all the disconnect operating handles. This standardized the method of mounting and attaching the interlocks to the operating handles. The interlocks are all arranged so that the one key in the upper row (Fig. 15) is released and the two keys in the lower row retained in the interlock when the handle is in the upper position as shown. When the handle is in the lower position, all three keys are released. In order to move the handle from one position to another, it is necessary to have all three keys in the interlock. The withdrawal of any one from the interlock, locks the handle in position.

As an example of the operation of the interlock system, let it be desired to ground the circuit in position 14. Fig. 16 in a schematic diagram of positions 8 and 14, and the bus disconnects with the respective interlocks. The normal operating condition of circuit No. 14 is with the ground switch open and with both oil circuit breakers with their respective disconnects closed to both buses. The key locations for the above operating condition is as follows: Keys Nos. 26 and 106 are in the respective oil circuit breaker interlocks, keys Nos. 9, 40, 89 and 68 are in the respective oil circuit breaker disconnect interlocks, and key No. 54 is deposited in the switchboard room. The first operation toward grounding the circuit is to open both breakers, which releases keys Nos. 26 and 106. Keys Nos. 26 and 106 are then deposited in the respective oil circuit breaker disconnect switch interlocks and the disconnects thrown to the open position. The keys Nos. 9, 40, 89 and 68 are accordingly released. Keys Nos. 40 and 68 are then deposited in the ground switch interlock and on proper notification from the load dispatcher that the line is de-energized, key No. 54, from the switchboard room, is deposited in the ground switch interlock and the ground disconnects closed. Key No. 54 is then returned to

the switchboard room. The ground switches are thus locked closed. The reverse operation of the above is necessary to remove the ground and restore the circuit to normal operation.

As an example of the operation of the bus and bus ground disconnects let it be desired to ground the lower main bus. The oil circuit breakers to the lower main bus are first opened and then the respective breaker disconnects. The keys in positions 9 to 14 inclusive (Fig. 14), corresponding to keys

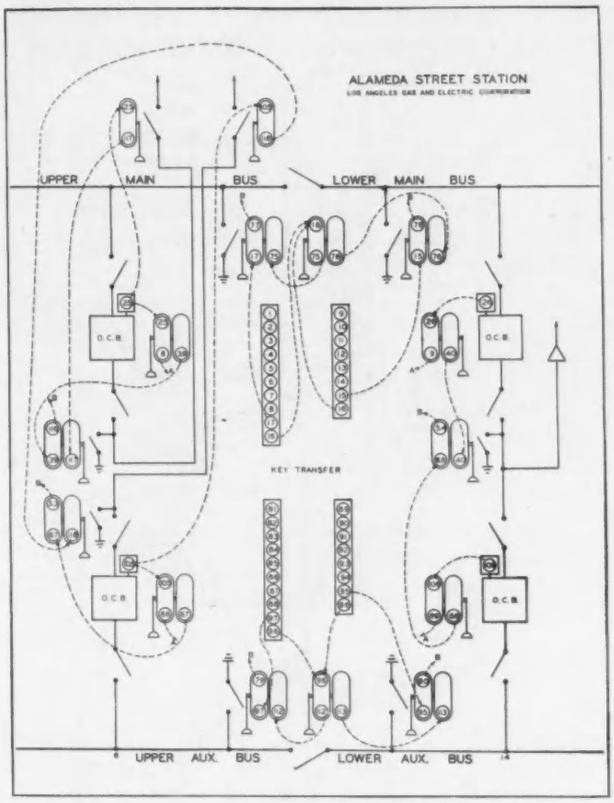

Fig. 16—Diagram of interlock scheme used at Alameda Street Station, Los Angeles Gas and Electric Corporation

Nos. 9 and 40 in position 14, are released from the respective interlocks by the opening of the breaker disconnects. The keys marked (A), corresponding to key No. 9, are then collected and deposited in the lower main bus key transfer. Fig. 17 shows one of the key transfers. On deposit of keys 9 to 14 inclusive in the transfer, keys Nos. 15 and 16 are released. Key No. 16 is then deposited in the main bus disconnect interlock and the bus disconnect opened. The opening of the bus disconnects releases keys Nos. 75 and 76. Key No. 76, together with key No. 15 from the key transfer and key No. 78 from the switchboard room, are deposited in the lower main bus ground disconnect interlock and the ground disconnect closed. Key No. 78 is then returned to the switchboard room and the ground switch locked closed until the return of the key. Until the bus ground switch is opened and keys Nos. 15 and 16 are returned to the key transfer, the oil circuit breaker disconnects to the lower main bus cannot be closed, thus preventing the closing of a breaker to a grounded bus. The reverse of the above operation is necessary to remove the ground and restore the bus to normal operation. In like manner other switching operations are performed.

It will be noted that the interlock system does not require additional movements over and above those required for normal operation of the disconnuects, with the exception of transferring the keys. The oil circuit breaker interlocks

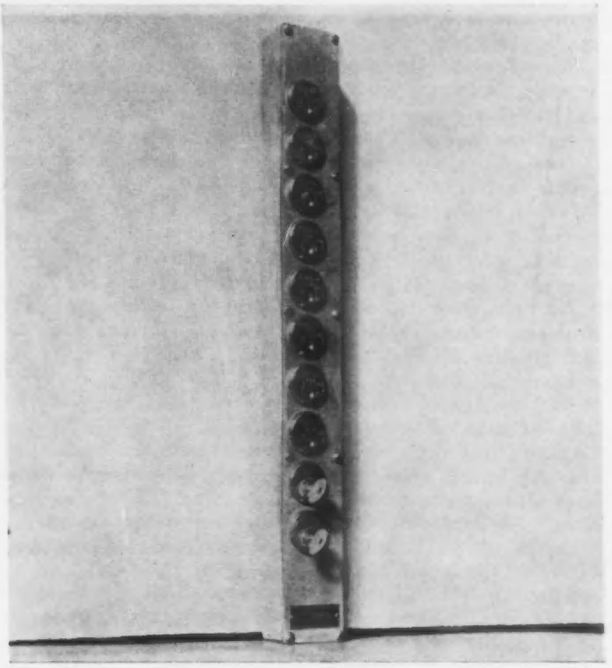

Fig. 17—Interlock key transfer

are located conveniently close to the disconnect switch operating handle and, as a result, to operate the disconnect switches it is only necessary to approach the operating handle, deposit the required keys, throw the handle, pick up the required keys from the interlock, and proceed with the switching operation.

The cost of installation of such a system is approximately $300 per position. A modified system of interlocking in which padlocks are used instead of the shaft locks on the disconnect-switch-operating handles has been installed in some of the distribution substations. The cost of such a system is approximately $250 per position for the same conditions and bus system as described above.

The results obtained from the use of the interlock system in the substations and switching stations appear to have justified the expenditure necessary for the installations. Since the installation of the interlock systems, there has not been a case, where the system has been intact, of the operating of disconnects while carrying load current or the closing of oil circuit breakers in the substation on a grounded bus.

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*Protective Engineering**

This subcommittee during the past year has undertaken the study of protective engineering under the following subjects:

1. *Causes of faults.*
2. *System set-up designed to minimize faults and their effects.*
3. *High-speed relays.*

Under the first topic considerable information was obtained, indicating a very small percentage of trouble due to faulty relays, incorrect relay schemes and mistaken or careless operation. By far the preponderance of

* Report of subcommittee on protective engineering, electrical apparatus committee, Engineering Section. C. W. White, chairman. Frank Ayres, G. M. Babcock, R. C. Denny, P. B. Garrett, F. Garrison, W. F. Grimes, J. P. Price, H. T. Sutcliffe, J. H. Vivian, R. Wilkins.

trouble was shown to be due to what might be termed legitimate trouble, such as lightning, birds, foreign matter in lines, etc.

No effort has been made to tabulate these causes of trouble, because of the rather incomplete returns from the member companies, and of the wide range of causes given by those who have made reports.

One of the major problems that sooner or later confronts those charged with the planning, design and operation of a power system, is that of control of the short circuit kva. Such problems as system stability, circuit breaker interrupting capacity, costs, and allied problems, all reflect back to the one of short-circuit control.

No rule of thumb is possible for the solution of this problem, because of the many variable factors and the many types of systems involved. Each case must be studied individually.

The method of control of short-circuit kva. on the transmission system of the Southern California Edison Co. Ltd., is presented in this report in considerable detail. By means of sectionalizing the 66-kv. transmission lines into definite major substations and the further sectionalizing of the 66-kv. bus at these stations, the three-phase short-circuit duty, with present installed capacity, has been reduced from a maximum of 1,900,000 kva. to 990,000 kva.

Coincident with the demand for greater speed of relay operation, various schemes have been developed to eliminate or reduce the cascading of relay time-settings, an inherent fault with most schemes of system relay protection.

One such scheme, which is described in detail later in this report, is that of supervisory pilot-wire relaying, which is a modified form of pilot-wire relaying. In this scheme advantage is taken of spare conductors in a supervisory control cable between certain stations. The direction and magnitude of the current in the transmission line is determined by directional and overcurrent relays. These currents are not balanced one with the other, but the contacts of the relays at each station are connected in series by two pilot wires between the stations. A fault on the line will cause more than normal current to flow into the line from each station. The relays at each end of the line will close contacts and complete the tripping circuit over the pilot wires, opening the circuit breakers at both ends of the line. Fault current, flowing through the line to a short circuit on some other part of the system, will cause one of the directional relays to open its contacts and the line will not trip out.

Another scheme is that making use of a new instantaneous trip relay, installed on the lines at a major substation, in conjunction with the overload or directional relays.

This relay has four elements, three for phase and one for ground protection. The minimum trip setting of this relay is made to correspond to a short circuit on that line at some predetermined percentage of the distance out from the major substation to the first station on that line. If the short circuit occurs within this percentage of the line, the instantaneous relay will trip out the circuit at once. If, however, the short circuit occurs beyond this percentage of the line, the instantaneous relay does not operate.

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*Control of Short-Circuit KVA.**

Practices of the Southern California Edison Company Ltd. in the control of short-circuit kva. are here described.

* Report prepared by H. W. Tice, for subcommitteee on protective engineering, electrical apparatus committee, Engineering Section.

CONTROL of short-circuit kva. on the Edison system can be explained more clearly by referring to the schematic diagram of the transmission system (Fig. 1). The "backbone" of the Edison system is essentially a transmission system with 220 kv. for major transmission and 66 kv. for subtransmission. A large amount of synchronous condenser capacity is required for power factor correction and voltage regulation. This capacity adds materially to the short-circuit kva. available at any given point on the system.

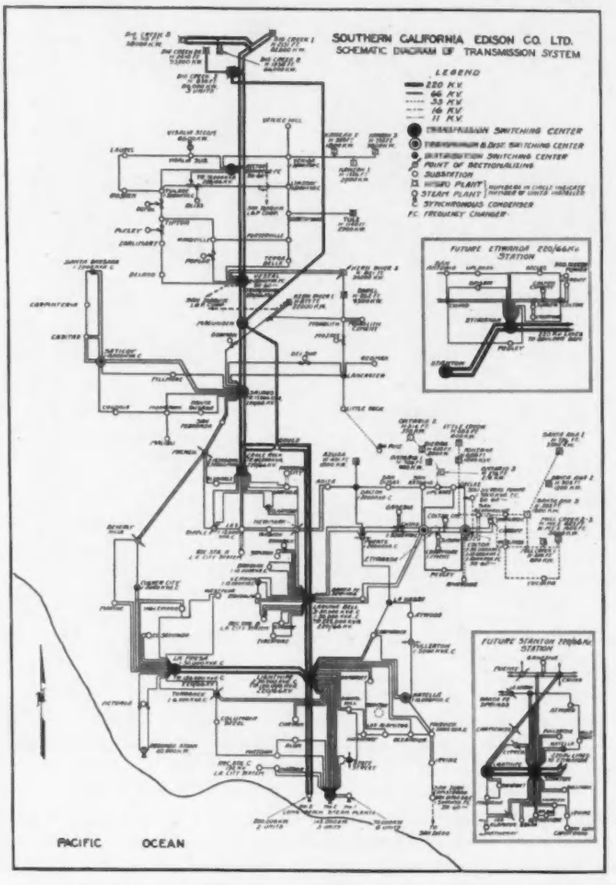

Fig. 1—Schematic diagram of transmission system—Southern California Edison Company Ltd.

For example, the total generating capacity is 950,000 kva., and the total synchronous condenser capacity is 550,000 kva., so that the total capacity to be considered under short-circuit conditions is 1,500,000 kva. Over half of this capacity is concentrated at the five major distributing points which are located within a radius of twenty miles.

It is within this area that short-circuit control has been a real factor. The first step was to sectionalize the 66-kv. system within this area into four major groups, interconnected only through the 220-kv. system. This was accomplished by sectionalizing the 66-kv. system, which normally operated as a closed loop, at such points as Macneil, Beverly, Newmark, Torrance, etc. This was quite simple, as each one of those key stations was already equipped with double bus and a pair of oil circuit breakers per line, and it was largely a matter of selecting the proper lines and loads for each separate group. This arrangement was found to be very satisfactory as to loading of lines, voltage conditions, relay protection and reduction in short-circuit kva. Such stations as Torrance, Beverly, Macneil and Newmark, dropped from 1,500,000 kva. to half that value, which brought the short-circuit kva. within the rating of the oil circuit breakers. The

next step was to sectionalize the 66-kv. buses at such major stations as Eagle Rock, Laguna Bell and Lighthipe. This required further sectionalizing on the 66-kv. system in order to create six separate 66-kv. groups instead of three.

The maximum capacity of any group is 150,000 kva. of interconnection with the 220 kv. and 150,000 kva. of synchronous condenser capacity. The minimum capacity consists of a 75,000-kva. bank of transformers and 50,000 kva. of synchronous condenser capacity. The maximum short-circuit kva. that can now be obtained on a 66-kv. bus is 90,000 kva., as compared with 1,990,000 kva. before the separation. The reduction in short-circuit kva. within this area is shown in Table I.

TABLE I—66-KV. SYSTEM

Station	Col. I 3-ph., Short-Cir. kva. With 1,500,000 kva. Syn. Cap. System Normally Sectionalized	Col. II Same as Col. I Without Sectionalizing	Col. III 3-ph., Short-Cir. kva. with 850,000 kva. of Gener. and 350,000 kva. of Syn. Cond. Cap. Added to Pres. Cap. System Norm. Sectionalized Total Cap. 2,700,000 kva.	Col. IV Same as Col. III Without Sectionalizing
Laguna Bell	990,000	1,900,000	1,050,000	2,280,000
Lighthipe	860,000	1,900,000	1,400,000*	3,100,000
Long Bch. No. 2	790,000	1,745,000	1,110,000	2,700,000
Eagle Rock	740,000	1,800,000	770,000	1,980,000
La Fresa	775,000	1,550,000	600,000†	2,150,000
Newmark	705,000	1,550,000	760,000	1,800,000
Torrance	670,000	1,540,000	540,000‡	2,130,000
L. A. 3	610,000	1,180,000	630,000	1,300,000
Puente	580,000	1,140,000	600,000	1,300,000
Chino	565,000	885,000	580,000	960,000
State Street	550,000	1,400,000	740,000	1,950,000
Katella	510,000	870,000	640,000	1,050,000
Saugus	505,000	790,000	530,000	840,000
Glendale	495,000	1,220,000	515,000	1,300,000
Colton	450,000	590,000	450,000	620,000
Macneil	290,000	1,200,000	270,000	1,350,000
Beverly	250,000	1,000,000	265,000	1,240,000

*Two 75,000-kva. banks, two 50,000-kva. condensers per section can be reduced to 700,000-kva. by further sectionalizing.
†66-kv. buses sectionalized, one 75,000-kva. bank, one 50,000-kva. condenser as compared with two 75,000-kva. banks, one 50,000 condenser, Col. I.
‡Result of change at La Fresa.

TABLE II—220-KV. SYSTEM

Station	Col. I 3-ph. Short-Cir. kva. with Present Capacity of 1,500,000 kva., Parallel Operation	Col. II 3-ph. Short-Cir. kva. with a Total Capacity of 2,700,000 kva., Parallel Operation	Col. III 3-ph. Short-Cir. kva. after Re-arranging Lines and 220-kv. Inter-connections. Total Cap., 2,700,000 kva.
Magunden	1,840,000	2,095,000	1,940,000
Saugus	1,860,000	2,400,000	2,020,000
Gould	2,290,000	3,160,000	2,600,000
Eagle Rock	2,170,000	3,100,000	2,440,000
Laguna Bell	2,480,000	4,500,000	2,340,000
Lighthipe	2,490,000	5,100,000	2,300,000
Long Bch. No. 3	2,400,000	5,400,000	1,460,000

Column I shows the maximum short circuit available on a three-phase fault under normal conditions of operation, that is, all sectionalizing points being normally open. Column II shows the maximum short-circuit kva. available on a three-phase fault before any attempt was made to reduce the short-circuit kva.

A comparison of columns I and II shows the marked reduction in the maximum short-circuit kva. available with the present installed capacity. The reduction ranges anywhere from two to one at the major stations, to four to one at some of the sectionalizing points.

Column III shows the short-circuit kva. available by increasing the generating capacity by 850,000 kva., and the synchronous condenser capacity by 350,000 kva., giving a total capacity of 2,700,000 kva. In other words, by practically doubling the present capacity, the short circuit is still within the rating of the oil circuit breakers. In the case of Lighthipe it may be necessary to sectionalize into four 75,000-kva. groups instead of two 150,000-kva. groups. This would then limit the short-circuit kva. to less than 1,000,000 kva.

Column IV shows what might be expected in the way of short-circuit kva. with a 2,700,000-kva. system and parallel operation.

The breakers at the major stations are rated at 1,500,000 kva.; however, at many of the close-in 66-kv. stations breakers are rated from 500,000 kva. to 1,000,000 kva. Experience has shown that it is well to keep the short-circuit kva. considerably below the theoretical rating of the breakers.

With the plan as outlined for the 66-kv. system, it is an easy matter to limit the maximum short circuit to a 1,000,000 kva. even after doubling the present installed capacity. This plan of operation has resulted in the minimum number of switch changes, and the cost of obtaining this short-circuit control is negligible because there has been no additional equipment installed for this purpose alone. At such stations as Eagle Rock, Laguna Bell and Lighthipe, with twenty to thirty 66-kv. line positions, bus-sectionalizing switches are normally installed to sectionalize automatically the buses in the event of a bus failure.

It is the double-bus arrangement and bus-sectionalizing switches that give the system sufficient flexibility to carry out this scheme of short-circuit control.

This particular method of operation on the 66-kv. system has proved to be quite simple, effective and inexpensive, and it appears to be the logical course to follow on the 220-kv. system as additional capacity is installed and short-circuit kva. control becomes necessary. Up to this time, the only control on the 220-kv. system has been that of ground current. The later transformers have been specified with 73-kv. neutral insulation and reactors or impedors installed in the 220-kv. neutrals. The effect of this control is barely noticeable on account of the large amount of transformer capacity that is solidly grounded. The effect of reactors in 345,000 kva. of transformer capacity has been to reduce the total ground current from 5 per cent at Laguna Bell to 10 per cent at Long Beach No. 3.

The records for 1929 and 1930 indicate that 17 per cent of all 220-kv. trouble involved more than one phase, and that 6 per cent involved all three phases. This means that short-circuit-kva. control on the 220-kv. system must be considered under three-phase fault conditions. The value of three-phase short-circuit kva. on the 220-kv. system, as shown in column I, Table II, are up to and, in some cases, in excess of the rating of the present breakers. Column II shows the short-circuit kva. that can be expected by increasing the present synchronous capacity from 1,500,000 kva. to 2,700,000 kva. These values are 100 per cent in excess of the rating of the present breakers, and it will be necessary to have some control over the maximum short-circuit kva.

One scheme for the 220-kv. system consists of establishing four 200,000-kw. load centers, supplied directly from Long Beach No. 3 at 220 kv. Each load center is sectionalized on the 66-kv. system with 100,000-kva. transformer units per section as the normal feed. Each section is also interconnected with the 220-kv. system through 75,000-kva. transformer units. These units serve as a point of exchange and an alternate feed for each group. In each case there are two banks per line interconnected on the 66-kv. system only. The short-circuit kva. for such an arrangement is given in column III, Table II, for a total system capacity of 2,700,000 kva. These values are practically the same as the short-circuit kva. at the present time with a 1,500,000-kva. capacity. Such an arrangement results in a practical, economical and extremely flexible arrangement on the 220-kv. system doubling the present capacity without increasing the short-circuit kva. beyond the rating of the present breakers.

The distribution system requires an equal amount of study in order to obtain the desired results at the minimum cost. Distribution substations, such as Vernon on the 16-kv. system, and State St. on the 11-kv. system, have a capacity of 30,000 kva., with maximum short-circuit values of 320,000 kva. at Vernon and 250,000 kva. at State St. In each case

the feeders are relatively short and heavily loaded and, in order to protect the equipment at consumers' stations and out on the line, it is necessary to limit the short-circuit kva. to 100,000 kva. and less. In such cases, 300-amp., 5 per cent line reactors are installed, which limit the short-circuit kva. at Vernon to 120,000 kva. and at State St. to 80,000 kva. In these two cases it was necessary to resort to line reactors in order to limit the kva. to the values shown; however, in many other cases the short-circuit kva. can be held within the required limits by installing one bus-sectionalizing switch and operating the transformers separately instead of in parallel operation. In such cases line reactors are not needed and quite a saving is effected. There is a total of 410 16-kv. and 11-kv. circuits on the Edison system, 38 per cent of which are equipped with line reactors.

In summing up the subject of short-circuit control on the Edison system, it is evident that almost any degree of control can be obtained by simply operating a number of small units instead of large concentrated blocks of power; second, that the cost of obtaining such control is negligible compared with the beneficial results that are obtained by operating in such a manner; third, group operation on the 66-kv. system has eliminated the heavy short-circuit kva.'s that formerly caused instability of the 220-kv. system and thereby has greatly improved the quality of service; fourth, oil circuit breaker failures have been practically eliminated and the cost of overhaul and maintenance reduced to a minimum; fifth, group operation has simplified dispatching to such an extent that it is possible to dispatch all operations through the medium of switching centers in each group, thereby eliminating all time delay in restoring service following an interruption; sixth, another outstanding benefit of group operation is the improvement that has been obtained in the performance of the protective relays. And, most important of all, the quality of service has been improved and the cost of electrical energy to the consumer has been reduced.

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*Adaquate System Protection**

A discussion of the relay requirements of transmission systems with supporting operating data.

RELAY protection to be adequate, would, according to Webster, have to be equal to what is required; suitable to the case or occasion; or on the whole, fully sufficient. The requirements, then, for a fully sufficient system protection would be that each and every operating unit of the system should have its own relays, which would immediately remove the unit from service on the occurrence of troubles within it.

Operating units of a power system may be classified as the generators, or synchronous condensers, transformer banks, buses and lines. It is chiefly desirable that any of these units shall clear out not only in a minimum of time, but shall do so without affecting any of the related units. This is an ideal condition, and like all ideals falls short to some extent in practice. Just how near it is possible to secure adequate system protection and whether this is justifiable at all costs, are problems considered in this paper.

Rural electric service of today has become very exacting, owing to the wide use of electric ranges, probably more than to any other of the household devices. It is perhaps not so bad to have to light candles to see by when the electricity "goes off," but it would prove most irksome to have to wait around hungry when the power was off at mealtimes. Inasmuch as the majority of electric ranges, perhaps 70 per cent, are in use in rural communities, it is imperative that the substations serving such communities receive no unnecessary interruptions.

Rural substations no doubt present the biggest problem on transmission systems, in so far as continuity of service is concerned. Usually they are cut into transmission loops, so that they may always have power from one side or the other. Very often there are several of these substations in a loop, so that it becomes most important that the discriminatory action of the relays be correct. On many systems such loops are eventually extended to form interconnected loops or networks, a practice which usually complicates the protection problem.

On the other hand, the importance of the service to large load centers calls for more lines, usually in parallel arrangements, which simplifies the protection problem. Thus there are apparently two conditions set up that seemingly are paradoxical, or perhaps simply economically inconsistent. Nevertheless, the problems exist and must be dealt with, in as satisfactory a manner as possible for the good of the service.

System protection as a whole should be more or less subservient to system operation. It should possess that flexibility which would permit almost any unit, or, indeed, several units, being taken out of service, without necessitating readjustments. Such perfection is, of course, unheard of. However, the question is, how near is it possible to approach such a set-up? On the present day extensive power systems, the dispatcher's office has become more or less a clearing-house for records and the dispatcher himself something between a statistician and an accountant. He is depending more and more upon the relays of the system to ferret out the troubles and re-establish normal service.

This is perhaps as it should be, if funds are available to keep a system up to date, as new and better relays are developed. Therein lies the root of the difficulty. The science of relaying lagged somewhat behind the growth of power systems, until most systems were quite saturated with the older types of relays, long before the more desirable types were available. Thus the question has become, it would seem, one of economy—whether the additional improvement in service to be secured by the use of the last word in relays (granting the existence of such) would compensate for the retirement of the older relays.

Perhaps a study of the relay operations on one of the California power systems might prove of some value in connection with the above question. Exclusive of distribution circuits, there are on this system a total of 135 operating units protected by induction-type relays in approved connection schemes. These relays represent an investment of $37,765, or $280 per operating unit. Practically 60 per cent of the units are located on 1,800 miles of transmission lines, operating at 110 kv. and 70 kv., protected by directional overload relays, in which there is an investment of $31,600. These relays have, in the past two calendar years, averaged 93.1 per cent correct in their operations, the analysis of which is shown in Table I.

It might perhaps be of some interest to turn aside at this point to consider the causes of faults which are more or less common to all transmission systems. There is attached to this paper a list of some 35 types of fault causes. Also, a tabulation has been prepared, showing by months the number of each of these causes over the same two-year period mentioned in the preceding paragraph. These average something over sixteen faults per month. The purpose in keeping up such a record is to study the various causes with the idea of eliminating as many as possible by improvements in design and construction or by other precautions.

Most prevalent among the causes, it will be noticed, are those due to birds and to lightning. Insulator failures come in for a large share, the majority occurring on the older pin-type lines. Lines swinging together, the outstanding item in 1930, was an unusual condition, owing to unprecedented snow storms at low elevations. Many troubles are put down as "cause unknown" because no evidence of the

* Report prepared by R. C. Denny for subcommittee on protective engineering, electrical apparatus committee, Engineering Section.

cause has ever been found. It is the writer's opinion that these might be attributed fifty-fifty to birds and lightning. Regardless of the good work that is going on to prevent faults, it appears that there is about as much trouble one year as another, which only demonstrates that eternal vigilance is still in order.

Referring again to Table I, it will be noticed that a considerable number of operations are listed under classification No. 2 as correct. Technically they were correct, so far as directional overload operation was concerned; however, they were just not necessary. Notwithstanding the fact that these unnecessary tripouts caused very few interruptions to substations, they do represent an inadequacy in relaying. This condition has developed incidentally to the interconnection of graded loops, in that trouble adjacent to a high setting in one loop operates a relay of lower setting in an adjacent loop. It is also true that only a few of the operations classed as incorrect actually cause interruptions, in fact, the percentage of continuity of service to substations is well over 99.9 per cent.

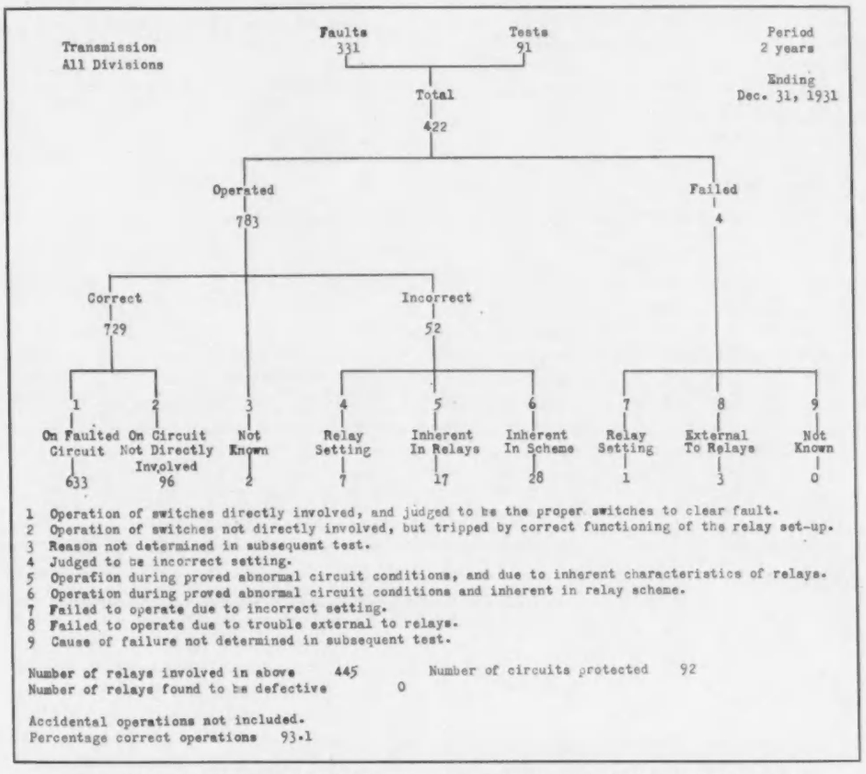

TABLE I—ANALYSIS OF RELAY OPERATION DURING PAST TWO YEARS

TABLE II—INDEX OF TRANSMISSION FAILURES, 1930-1931

Type
1. Insulator failure, mechanical.
2. Insulator failure, electrical. All flashover failures not classified below.
3. Poletop fire or burned crossarm.
4. Pole burned by secondaries.
5. Pole burned by grass or other fires.
6. Poles or crossarms broken off by autos, airplanes, etc.
7. Pole falling over, due to high winds, soft ground, landslides, etc.
8. Pin broken, burned, pulled off, or insulator off pin.
9. Broken hookbolt or other suspension hardware.
10. Broken or loose tie-wire or clamp.
11. Line broken at clamp, cut by tie-wire, or worn at insulator saddle.
12. Splice or connection failure.
13. Line wire broken—other causes.
14. Birds or animals in line or in station equipment, and trouble due to bird droppings.
15. Tree in line.
16. Masts, derricks, dredges, debris or other foreign matter in line.
17. Line wires swinging together.
18. Line wires swinging into tower or crossarm.
19. Guy wires in contact with power lines.
20. Secondary lines in contact with transmission lines.
21. Telephone lines in contact with transmission lines.
22. Flashover between phases due to fire under line.
23. Lightning—all trouble due to lightning.
24. Defective station high-tension equipment causing an interruption to transmission lines.
25. Defective station equipment, other than high-tension, causing an interruption to transmission lines.
26. Leaky roofs, etc.
27. Defective line air-switch or air-switch insulator.
28. Trouble originating on secordary lines, causing an interruption to transmission lines.
29. Trouble on foreign systems causing an interruption.
30. Overloads.
31. Accidental tripping of line switch.
32. Mistake in switching, reversed phases, or carelessness of employees.
33. Malicious mischief.
34. Accidents to persons.
35. Unknown troubles.

Viewing such figures, one might doubt the wisdom or necessity of revamping an entire relay system. There is, however, another angle, so far not mentioned, which vitally concerns the relays of a system. This is the effect that the disturbance has on the system load, and the system stability as well. The load lost during a trouble condition holding longer than two seconds, may be considerable, although depending somewhat on the location with respect to the concentrated system load. This loss is seldom evaluated, but it does represent a loss of revenue which may greatly exceed the damage at the point of trouble. In fact, it may run into thousands of dollars per year. However, it is not all chargeable to the system relays, being partly due to consumers' no-voltage relays on which there is little, if any, time delay.

The effect of disturbances on system stability is apparent, at times, as voltage surging, or even in the form of plants so badly out of step that they must separate and re-synchronize. Such conditions are usually due to phase shorts, particularly in the case of three-phase shorts. It is desirable enough, for these reasons alone, that relay operations should be as fast as practicable, consistent with proper discrimination. In other words, it is probably important that line relays operate quite as fast as other types of protection, in the interest of the system operation as a whole. Fast opera-

TABLE III—SAN JOAQUIN LIGHT & POWER CORPORATION
SUMMARY OF TRANSMISSION LINE TROUBLES BY MONTHS

Classifications	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Totals
January 1930	1						1		1		3		5		3	1	15			1				2				4						1		38
February 1930			1										1		3								3										1	1	2	12
March 1930						1					1		1		2		6				1		1												1	14
April 1930			2								2		1	4									1	2				1			1		1		15
May 1930			2								1			1		1								1	1						1				8
June 1930							1						1	3																				1	6
July 1930		1					1							2										1											5
August 1930		8									1			3									2											1	15
September 1930		1			1						3												8												13
October 1930			1								1	1							1																5
November 1930		2	2								2				3	1	8						1	3				1						1	24
December 1930						1					1			3										2	2									1	10
Totals	1	12	8		1	2	3		1		15	1	9	16	11	3	29		1	1	1		16	11	3			5	1			2	1	2	9	165

January 1931		1	1								1			2										1							1				7
February 1931		2													1								4	1											8
March 1931					1																			2			1				2	1		3	10
April 1931		3	4			1									1	2	1	2					2								1				17
May 1931			4								1			5	1								4	3				1						2	21
June 1931		4			2					2				3									14		1									2	28
July 1931		3			1									8																					12
August 1931		2	2		1									1	1									1											8
September 1931		1	1											2									3												7
October 1931		5	1								1			4														1						3	15
November 1931				2							5			3	2													2						2	16
December 1931						3								2			1	3						1				2	1		1			3	17
Totals		21	13	2	5	1	3			2	8			30	6	3	4	2					27	9	1		1	2	5		1	4	1		15	166
1930	1	12	8		1	2	3		1		15	1	9	16	11	3	29		1	1	1		16	11	3			5	1			2	1	2	9	165
Grand Total	1	33	21	2	6	3	6		1	2	23	1	9	46	17	6	33	2	1	1	1		43	20	4		1	7	6		1	6	2	2	24	331

tion may be secured with ordinary induction-type overload relays in the case of generator, transformer, bus and parallel-line protection by adhering to time-honored differential connections.

Such is not the case with single-line loops, except at considerable expense for pilot wires or carrier-current apparatus. Both of these schemes would have objections other than their first cost on extensive transmission systems, and so are practically out of the question. The nearest approach to these requiremtns of speed with discrimination are the so-called distance relays or those operating on the impedance or reactance principle. The development of these relays was indeed an effort in the right direction. It is unfortunate that they came along so late, for it is extremely doubtful if any company would discard the induction-type overcurrent relays of its system, in favor of the later type. However, the operating principle of these new relays is most fascinating.

Some years ago the writer advocated the idea of combining the induction-type undervoltage relay with the induction-type directional overcurrent relay as a means of taking advantage of voltage drop in times of trouble. It is still his opinion that such a combination has good possibilities. Directional overcurrent relays are now being connected, so that the directional element controls the operation of the overcurrent element, the closing of the contact of the latter tripping the breaker. It would therefore be most feasible to introduce the undervoltage relay contacts into the trip circuit, in series with the overcurrent contacts. The voltage drop, being practically instantaneous, need introduce little or no time in the operation, and the overcurrent need be only enough to permit the one adjacent station to relay first, thus affording back-up protection for failure at that station.

Possibly, with such a combination, one might arrive at a fairly uniform time operation the system over and so improve the service considerably without having to discard any of the older relays. It is the belief of the writer that on widespread interconnected transmission networks, with scattered sources of power, there is little need of super-speed relaying. In fact, on many systems of the West, the high-voltage breakers that are installed would not do justice to modern high-speed relays. The real need, therefore, is not for such high-speed relays, as for more uniformity in timing, in order that troubles at the end of a line near the power source may be cleared as quickly as troubles near the far end of the line.

Obviously such a thing is impossible, unless voltage drop is utilized as a controlling factor. Voltage restraint of the overcurrent element of the directional relay might well be accomplished in the torque circuits, thus avoiding a complication of armatures, springs, contacts, etc. In other words, a voltage-restraint device, developed as an attachment for standard directional overload relays, would fill a long-felt want and should be in great demand. Until then, relays requiring comparitively long time-setting might be controlled externally, by means of undervoltage relays, as suggested, the time thus being reduced materially.

It may be concluded from the foregoing that a sweeping change in relays is not justifiable on any system having only a small percentage of incorrect operations, causing but few interruptions. However, when considerable system load is lost, due to delayed operations at certain points, it might prove money well spent to change to improved types of relays, as they should soon pay for themselves. Relay requirements on any given system change somewhat as the system expands; however, the course to be adopted should depend very largely on an analysis of system-wide operations, otherwise a great many good relays may be needlessly discarded.

Relay development is not dormant by any means, if one may judge by recent magazine articles. In the past, engineers of operating companies have had a hand in the development of relays, and it is to be hoped that in the future they may have the encouragement to continue their interest in such things.

*Supervisory Pilot-Wire Relaying—A Modified Form of Pilot-Wire Relay Circuit to Eliminate Cascaded Timing in Transmission Line Protection**

Difficulty has been encountered in rapidly clearing short circuits on a network of transmission lines operated by the Los Angeles Gas and Electric Corporation. The present arrangement of the network is found to be the most economical scheme for the particular area which it serves.

This paper describes a relay scheme developed for quickly clearing line faults on the network. The scheme is made economically possible by using spare wires in the 20-pair No. 19-gage telephone cables already installed by the corporation for operating supervisory controlled substations.

The relay circuit is somewhat similar to the conventionally understood "pilot wire relay circuit." In the circuit herein described, the direction and magnitude of the current in each end of the transmission line is determined by directional and overcurrent relays. These currents are not balanced one with the other, as in the conventional pilot wire relay circuit, but the contacts of the relays at each station are connected in series by two pilot wires between stations. A fault on the line will cause current above normal value to flow into the line from each station. The relays at each end of the line will close contact and complete the tripping circuit over the pilot wires for opening the circuit breakers at both ends of the line. Fault current flowing through the line to a short circuit on some other part of the system will cause one of the directional relays to open its contacts and will not trip out the line.

ON TRANSMISSION loops and networks it is often difficult and sometimes impossible to secure proper clearing of line faults with the ordinary directional and overcurrent relays, using cascaded timing. In those cases the stations most distant from the generating or main switching station have their overcurrent relays set to operate as rapidly as possible. The time-setting of the relays at each successive station closer to the generating station is increased, to allow time for the circuit breaker to open at the preceding station. Clearing of the heavy faults close to the main source of power is therefore delayed, causing serious system disturbances, which sometimes exist long enough for synchronous apparatus to drop out of step.

A modified form of pilot-wire relaying is being used by the Los Angeles Gas and Electric Corp. to eliminate sequence relaying. The fundamental circuit, as shown in Fig. 1, is obtained by installing at each end of the transmission line a three-phase directional relay having its contacts in series with each of three overcurrent relays, one on each phase. The relays on each end of the line are connected in series by two pilot wires between stations. The directional relays are connected so as to close contact only when current flows from the station into the line. Thus, with a short circuit on the transmission line, current will flow into the line from both stations, the directional and overcurrent relays will close their contacts, and the circuit will be completed for tripping both oil circuit breakers. Both stations must have some source of supply other than the line to which this protection is being applied. With a current flow straight through the line to a fault on some other part of the system, one or the other directional relay, depending on which direction the current is flowing, will open its contacts and the tripping circuit will not operate.

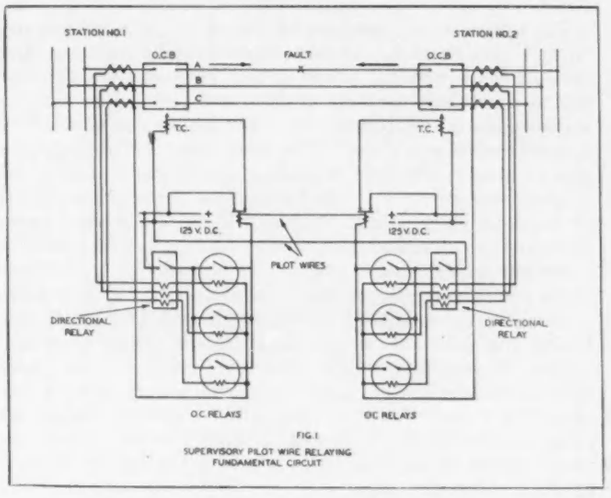

Fig. 1—Supervisory pilot-wire relaying—fundamental circuit

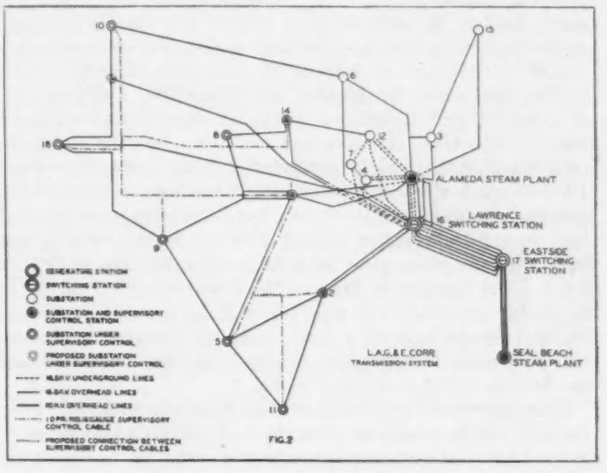

Fig. 2—Los Angeles Gas and Electric Corporation transmission system

The Los Angeles Gas and Electric Corp. system, as shown in Fig. 2, has a number of substations operating under supervisory control over its own 20-pair, No. 19-gage telephone cables. These cables contain extra wires available for pilot-wire relaying. At the present time this form of pilot-wire protection is being used for the 16.5-kv. lines between substations No. 8 and No. 14, between No. 1 and No. 5 and between No. 2 and No. 11. A similar scheme is now being installed on the lines between substations No. 18 and No. 19, No. 1 and No. 9, and No. 5 and No. 9. At some future date it is proposed to connect the supervisory control cables at two places as shown, at which time pilot wires will then be available to protect the lines between substations No. 2 and No. 5, No. 5 and No. 11 and between No. 1 and No. 8, No. 18 and a future station, and No. 10 and the future station. The regular overcurrent relays with directional relays, where necessary, are still being used as back-up protection on lines protected with this pilot-wire circuit. With modifications in the details of the circuit, supervisory pilot-wire relaying could be operated over leased telephone lines.

The difficulty of applying time sequence relaying to the network can be seen from the system diagram.

The schematic diagram of the tripping circuit is shown in Fig 3, overcurrent relays being shown for only one phase.

* Report prepared by G. M. Babcock.

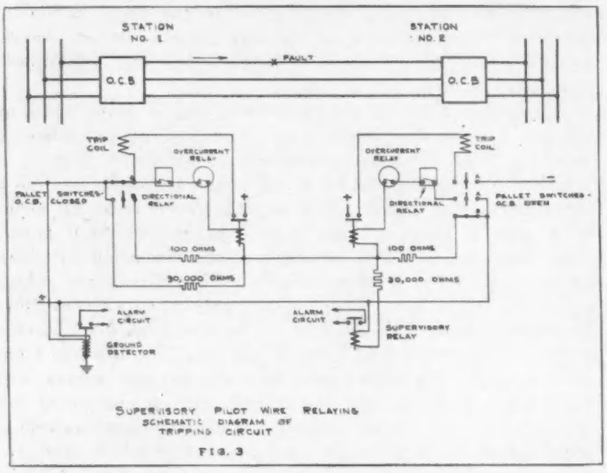

Fig. 3—Schematic diagram of tripping circuit

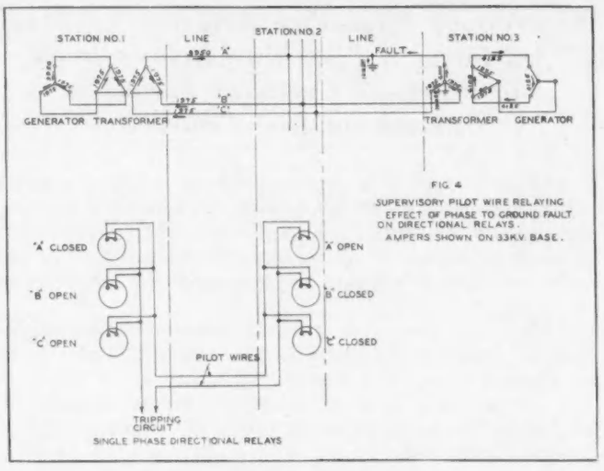

Fig. 4—Effect of phase-to-ground fault on directional relays

If the line is shorted when out of service and if either breaker should be closed against the fault, the breaker will trip out immediately. This is accomplished by having a pallet switch on each breaker bypass the overcurrent and directional relay contacts through a resistor. For example, should the breaker at Station No. 1 be closed with a fault on the line, when the breaker at Station No. 2 is open, the overcurrent and directional relays at Station No. 1 will instantly close their contacts and the circuit will be completed from negative battery at Station No. 1, through pallet switch (A), through the overcurrent and directional relay contacts and the auxiliary relay coil, out over the pilot wire, through the resistor and pallet switch (B) at Station No. 2, and back over the other pilot wire to positive battery at Station No. 1. The breaker at Station No. 1 will relay out instantly. A similar operation will take place if the breaker at Station No. 2 is closed against a fault when the breaker at Station No. 1 is open, the tripping circuit being completed through the bypass resistor at Station No. 1.

Ground relays with contacts in multiple with the overcurrent relays could be used in this circuit. However, a ground fault of any magnitude will be reflected in one of the overcurrent relays for tripping. Ground faults of values less than the overcurrent relay setting can be taken care of by the cascaded timing relay circuit without serious results from the longer time in clearing the fault.

A supervisory relay is connected across the pilot wires at Station No. 2 to give an immediate alarm if the two pilot wires become shorted or either wire opened. This relay requires a very small amount of current to remain energized. It is fed from the battery at Station No. 1 through a 30,000-ohm resistor, out over one pilot wire, through the supervisory relay and back over the other pilot wire. Should either wire open up or should they become shorted together by a resistance of 5,000 ohms or less, the supervisory relay will drop out and sound an alarm. Referring to Fig. 3, the 30,000-ohm resistor at Station No. 1, connecting negative battery to the pilot wire, is of sufficient resistance to limit the battery voltage well beyond the point of interfering with the proper operation of the main tripping circuit. The 30,000-ohm resistor, in series with the supervisory relay at Station No. 2 limits the current when negative battery is connected to the pilot wire through the 100-ohm resistor, when the breaker at Station No. 1 is opened.

A ground-detector relay is connected to the station battery and will operate on grounds of 2,500 ohms or less. This ground detector circuit is the same as that developed by the Southern California Edison Co. and described by T. J. Lovell of that company in the August, 1928, issue of *Electrical West*.

A three-element directional relay is used in preference to three single-phase relays. Under certain conditions a false operation might occur with the use of a single-phase element. An example of this condition is shown in Fig. 4. The system is being fed at one point by generators through delta-delta connected transformer banks and from another point by generators through delta-star connected banks with grounded neutrals. A phase-to-ground fault will be fed from the delta-delta banks out over the grounded-phase wire, through the ground to the grounded neutrals of the delta-star banks, through the two transformers on the ungrounded phases, back to the delta-delta transformer banks. If a line between Stations No. 1 and No. 2 is protected with this form of pilot-wire relaying, using single-phase directional elements, and a phase-to-ground fault occurred between Stations No. 2 and No. 3, the three overcurrent relays at Stations No. 1 and No. 2 will close their contacts. The single-phase directional relay on phase (A) at Station No. 1 would close its contacts and the single-phase directional relays on phase (B) and (C) at Station No. 2 will close their contacts. The tripping circuit between stations will be completed and the line between Stations No. 1 and No. 2 would relay out. As the power in phase (A) is equal and opposite to the sum of the power in phases (B) and (C), a three-phase directional relay at Stations No. 1 and No. 2 will open its contacts and tripping circuit will not operate with a fault beyond Station No. 2.

The overcurrent relays are set to operate at a value above normal load current, for with normal load conditions it is possible for directional relays at both ends of a transmission line to close their contacts at the same time. Fig. 5 shows a transmission line between two stations, at one of which is a synchronous condenser. The load being drawn from the line at Station No. 1, is at leading power factor, due to the synchronous condenser. At Station No. 2 the power factor of the load going out to Station No. 1 includes the power factor of the line, and although of leading power factor, is leading to lesser degree than that at Station No. 1. A three-phase directional relay connected with current coil in quadrature with a potential coil having its current lagging 40 deg. behind the potential, will reverse direction with a current leading 50 deg. from unity. Therefore under normal conditions, as shown in Fig. 5, the directional relays at both Stations No. 1 and No. 2 will have their contacts closed, the relay at Station No. 1 having reversed on account of the power factor of the load leading beyond the reversing point of the directional relay.

The overcurrent relays have sufficient time delay in closing their contacts to allow one of the directional relays to open its contacts in event of a fault beyond either of the stations, with conditions as stated above prevailing prior to the oc-

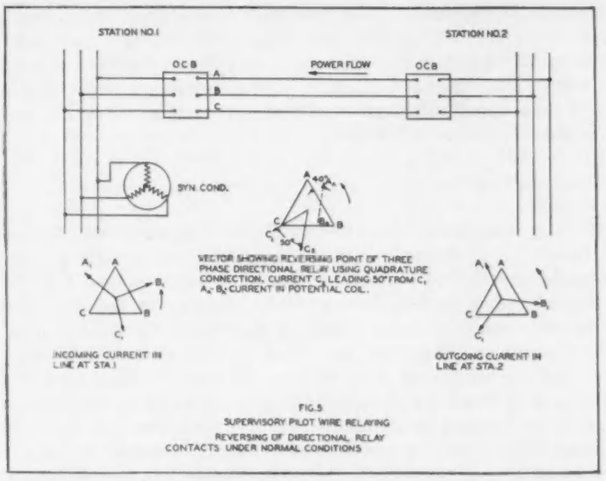

Fig. 5—Reversing of directional relay contacts under normal conditions

currence of the fault. Tests indicate that four cycles (0.7 sec.) is the maximum time for one of these directional elements to open its contacts under the worst conditions which are anticipated.

Solonoid-type overcurrent relays are used with a current setting of 1½ times full load and a time setting of 6 cycles (0.1 sec.) with twice the current setting of the relay.

The wiring diagram for testing the speed of directional relay contacts to close or to open with power reversal and system voltage drop are shown in Fig. 6. With the three-pole 110-volt three-phase supply switch closed, 1.25 amp. flow through the three-ohm resistors and directional relay to the load of three 50-ohm resistors. When the seven-pole switch is closed, 10 amp. will flow in the reverse direction, through the relay to the three-phase short across the 1-ohm resistors. The voltage on the potential coils of the relay will be reduced, due to the drop across the 5-ohm resistors, with 10 amp. passing through them. By reversing any two wires of the 110-volt three-phase supply, the direction of the relay will be reversed and the time for closing the contact can be tested. Various conditions of load and short-circuit current can be set up by changing the resistance values. The set-up shown was chosen to represent the worst condition to be encountered. With this condition, the directional relay opened contacts in 3¾ cycles and closed the contact in 8 cycles. As noninductive resistors were used in these tests, the relay torque was not as great as would be the case under operating

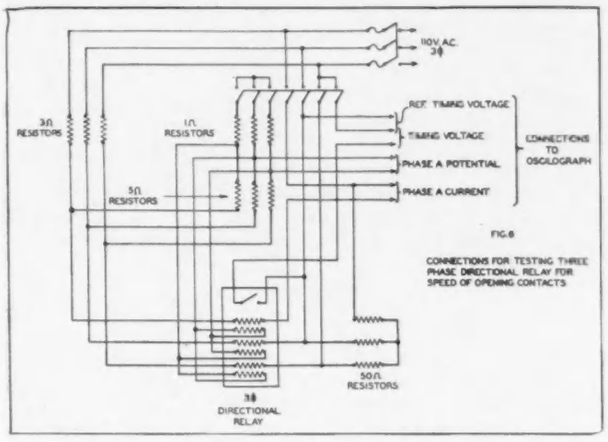

Fig. 6—Connections for testing three-phase directional relay for speed of opening contacts

conditions where the short circuit would have a lagging power factor. Therefore, under operating conditions, the time for closing or opening the contact would be slightly less than indicated in the tests.

The directional and overcurrent relays in this pilot-wire circuit can be replaced by one relay, this relay being a three-phase power directional relay having three-phase voltage restraint. Such a relay should have the advantage of contacts being open under all normal conditions, the amount of current required to close contacts varying in proportion to the voltage and varying inversely with the phase angle, having maximum torque with the current lagging 30 deg. The lower the voltage, the less current will be required to close the contact, and the larger the phase angle from maximum torque conditions, the greater the current necessary to close contact. Relays of this type are now in production as standard equipment.

This type of relay will be used on future installations of supervisory pilot-wire relaying by this company.

Tests indicate the present supervisory pilot-wire relay circuit will operate in 8 cycles (0.13 sec.) from the instant the fault occurs to the energizing of the trip coil of the oil circuit breakers. This relay circuit has the main requisites of a good protection scheme:

1. Fast operation in clearing line faults with either one or both breakers closed.
2. Non-operation for faults on other parts of the system.
3. Elimination of cascaded timing.
4. Standard equipment can be used.
5. Economical to install on the particular system to which it is being applied.

Two short circuits have occurred on lines protected with the pilot-wire connection. Both cleared correctly. No operations have taken place with through faults, although a number of severe through short circuits have occurred.

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*High Speed Relays**

Descriptions of two high speed relays in use on member companies' lines.

Type IT Relay‡

THE Southern California Edison Co. Ltd. 66-kv. transmission system is fed from the 220-kv. system at several major substations. The 66-kv. lines from these major stations feed their network separately from other major stations, thus each major station has a complete system of its own. In setting overload and directional relays in these separate networks, the relay timing is cascaded so that the relays at the major stations are necessarily set for a long time to secure proper discrimination. This means that the very heavy close-in short circuits hold on for the longest time.

In order to clear these close-in heavy short circuits quickly, the type-IT instantaneous trip relays are used in conjunction with the overload relays at the major stations. The minimum trip-setting of the IT relay is made to correspond with a short circuit on the line at a point 80 per cent of the distance out from the major station to the first station on that line. Therefore, if a short circuit occurs within this 80 per cent of the line, the IT relay will trip the circuit out instantly. However, should the short circuit occur in the 20 per cent portion of the line, the IT relay would not operate. The clearance of this short circuit depends upon the functioning of the normal overcurrent relays. These values are used

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* Report prepared for subcommittee on protective engineering, electrical apparatus committee, Engineering Section.

‡ Report prepared by L. F. Hunt.

to make sure the IT relay does not trip in case of through short circuits.

The standard type-IT relay has four elements, three for phase protection and one for ground protection. The nominal

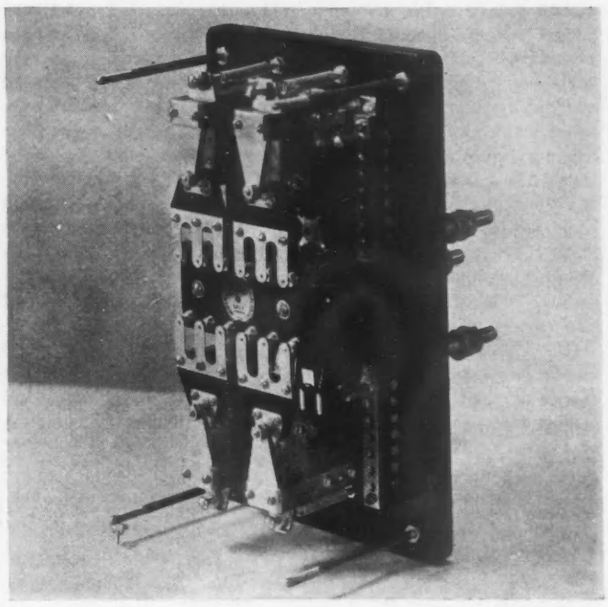

Fig. 1—Type-IT relay with cover removed

current taps on all four elements are 20, 25, 30, 40, 50, 60, and 75 amp. However, by adjustment of air gap and spring tension, any current-setting between 10 and 100 amp. can be obtained. The contacts of the four elements are connected in parallel. They are known as double-trip contacts so as to trip two circuit breakers independently. A gravity-type annunciator is used to give positive indication of relay operation. The cover of the relay is glass, thus making visual inspection possible without removing the cover. Cover studs are drilled for sealing.

High Speed Test Relay*

The San Bernardino substation of the Southern Sierras Power Co. is considered the principal tie point of the various transmission lines. Four of the main circuits feed into the 100-kv. high-tension bus at this station as follows: two circuits from the hydro plants in the North, the Hoover Dam transmission line, and the Los Angeles Gas and Electric Corp. tie-line from Seal Beach. Much trouble has been experienced in the past in testing these circuits following a relay operation, and occasionally considerable time has been lost when it was not considered desirable to test certain of the circuits directly from the main station bus. To eliminate this loss of time and to make it possible always to test these four circuits directly from the main bus, it was considered desirable to install certain high-speed relay equipment which would remove the line under test from the system in the matter of a few cycles, in case the fault still existed at the time of the test. Consideration was given to the various types of high-speed relays obtainable, with the result that a rather special type of equipment was employed.

The transmission system under discussion operates with a solid grounded neutral, and all four circuits mentioned are protected with both phase-to-phase and phase-to-ground relays in accordance with accepted practice. The new test relay equipment installed in no way displaces the existing protective relays. By means of a gang-operated current trans-

* Report prepared by Frank Ayres.

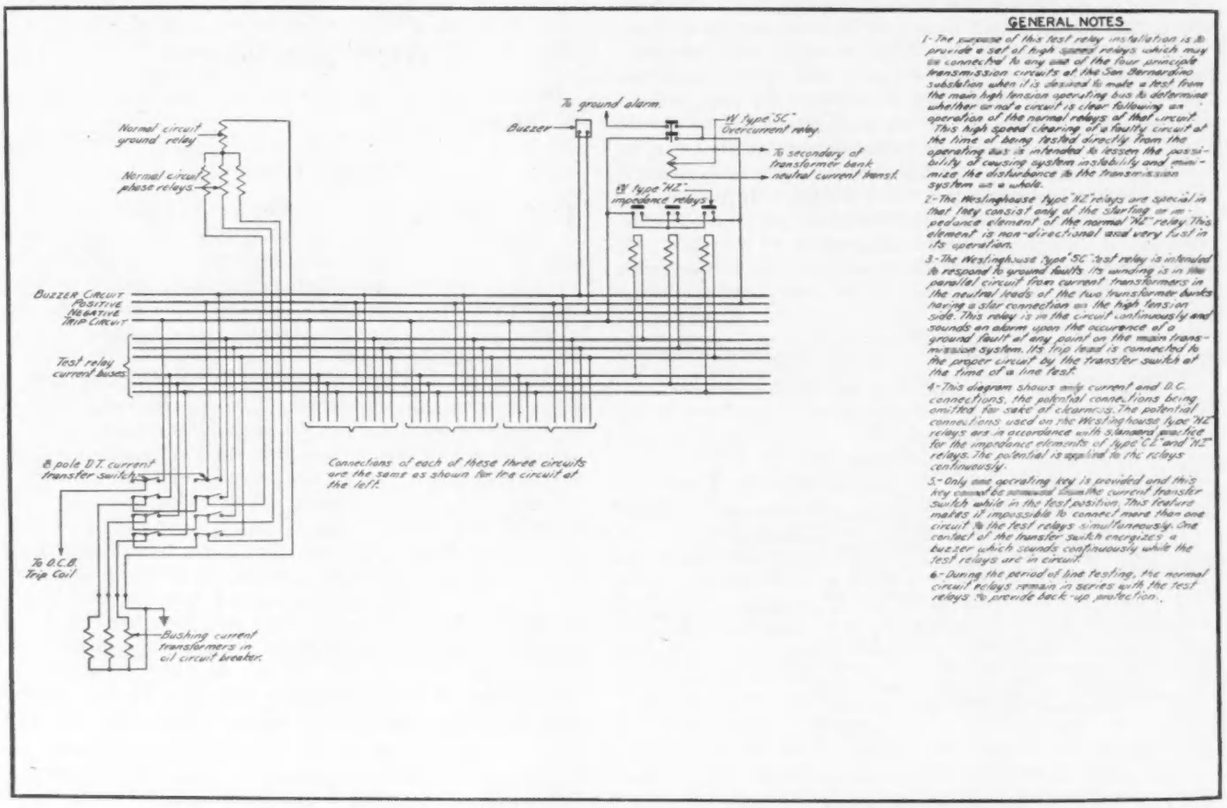
To ground alarm.
Buzzer
W type "SC" Overcurrent relay.
To secondary of transformer bank neutral current transf.
W type "HZ" impedance relays.
Normal circuit ground relay
Normal circuit phase relays
Buzzer Circuit Positive
Negative
Trip Circuit
Test relay current buses
8 pole D.T. current transfer switch
To O.C.B. Trip Coil
Bushing current transformers in oil circuit breaker
Connections of each of these three circuits are the same as shown for the circuit at the left.
GENERAL NOTES
1- The purpose of this test relay installation is to provide a set of high speed relays which may be connected to any one of the four principle transmission circuits at the San Bernardino substation when it is desired to make a test from the main high tension operating bus to determine whether or not a circuit is clear following an operation of the normal relays of that circuit. This high speed clearing of a faulty circuit at the time of being tested directly from the operating bus is intended to lessen the possibility of causing system instability and minimize the disturbance to the transmission system as a whole.
2- The Westinghouse type "HZ" relays are special in that they consist only of the starting or impedance element of the normal "HZ" relay. This element is non-directional and very fast in its operation.
3- The Westinghouse type "SC" test relay is intended to respond to ground faults. Its winding is in the parallel circuit from current transformers in the neutral leads of the two transformer banks having a star connection on the high tension side. This relay is in the circuit continuously and sounds an alarm upon the occurrence of a ground fault at any point on the main transmission system. Its trip lead is connected to the proper circuit by the transfer switch at the time of a line test.
4- This diagram shows only current and D.C. connections, the potential connections being omitted for sake of clearness. The potential connections used on the Westinghouse type "HZ" relays are in accordance with standard practice for the impedance elements of type "CE" and "HZ" relays. The potential is applied to the relays continuously.
5- Only one operating key is provided and this key cannot be removed from the current transfer switch while in the test position. This feature makes it impossible to connect more than one circuit to the test relays simultaneously. One contact of the transfer switch energizes a buzzer which sounds continuously while the test relays are in circuit.
6- During the period of line testing, the normal circuit relays remain in series with the test relays to provide back-up protection.

Fig. 2—Schematic wiring diagram of high speed test relays at San Bernardino substation

fer switch mounted on the main switchboard in the section allotted to each individual circuit, it is possible to cut the current circuit of the phase-to-phase test relays in series with the normal relays of the line to be tested. This same switch connects the trip circuit of the test relays in parallel with that of the normal circuit relays. Another contact of the same switch energizes a d.c. circuit which causes a soft-toned buzzer to sound continuously as long as the test relays are interposed in the circuit, in order to serve as a reminder to the operator that conditions are not normal, in case he should be called away from the switchboard. One of these switches is provided for each of the four circuits mentioned, but only one operating key is supplied, so that it is impossible for the operator to use the test relays on more than one circuit at a time. The operating key of this switch cannot be removed as long as the switch is in the test position.

For phase-to-phase protection, a special element was obtained for the test relays. The starting element of the type-HZ high-speed relay was installed in a regular type-CO relay case, three of these being used for this service. The back-up elements of the standard type-HZ relay were omitted. The potential circuit to these relays is kept energized continuously from the main relay potential bus. This insures that the contacts will be held open under normal conditions, thus preventing the possibility of closing the trip circuit through the test switch while the relay contacts are closed.

For phase-to-ground protection, a standard low-current-range type-SC relay is used. The current element of this relay is fed from the parallel connection of the secondaries of two current transformers, one of which is installed in the neutral of each of two grounded neutral transformer banks at the station. The current circuit of this relay is kept intact at all times, but the trip circuit will operate only when the test switch is closed. A second contact of this relay is connected to an annunciator position, to sound a warning to the operator whenever a ground condition exists on the transmission system, even though no relays may be called upon to operate at this particular station. This relay will operate for ground faults of less than 10 primary amp., and so far has worked out entirely satisfactorily.

*New Developments**

The subcommittee on new developments was organized this year for the purpose of providing an outlet for new ideas on subjects not covered by other subcommittees. Both the manufacturers and the operating engineers presented many fine papers and illustrated talks, some of which are reproduced in this report.

New Developments[1]

AS THE increase in density of population in Southern California Edison territory brought 4-kv. substations nearer to each other, there was greater need for establishing conditions such that the 4-kv. system from one substation could at times be connected in parallel with the 4-kv. system from another station, without interruption of service.

Many years ago certain connection standards for various system voltages were established on the Edison system.

The 66-kv. system phases (ABC) rotate counterclockwise 30 deg. ahead of the 220-kv. system.

The 16.5-kv. systems and 11-kv. systems rotate 30 deg. ahead of the 66-kv. systems, while the 4-kv. systems rotate 30 deg. behind the 16.5-kv. and 11-kv. systems, or in phase with the 66-kv. systems.

This makes it possible to tie-in a 4-kv. station, 66/4 kv., delta-delta, or star-star, with the stations which were delta-star, 16.5/4 kv. or 11/4 kv., but the desirable conditions attendant upon delta-star connections could not be realized on 66/4-kv. transformer banks on our system until this year, when the "zigzag" transformer was developed.

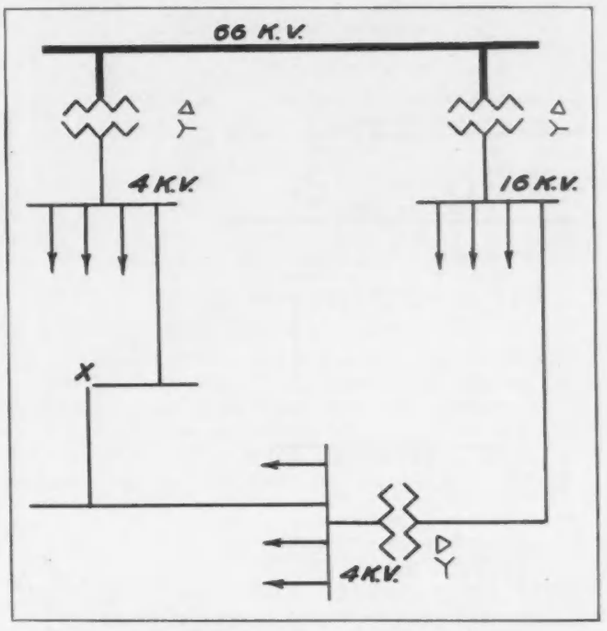

Fig. 1—Diagram illustrating that at point (x) lines cannot be paralleled because of being 30 deg. out of phase

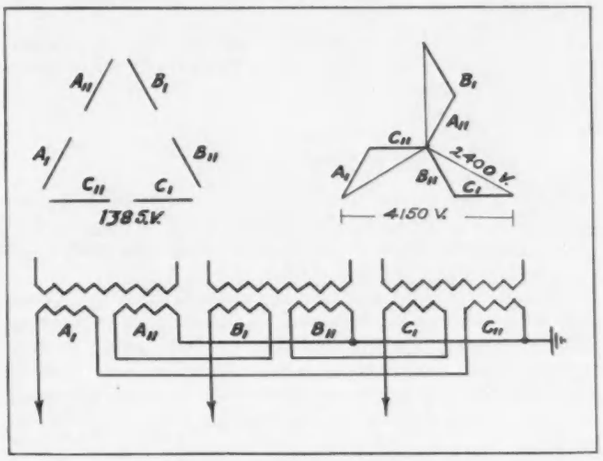

Fig. 2—Zigzag transformer connections

It will be seen that the problem to be solved was to transform energy from 66/4 kv. through a delta-star bank of transformers without creating a phase shift in so doing.

This problem was solved by using transformers, each with two 1,385-volt secondary windings which were interconnected between transformers in a zigzag star system, such that the phase shift of one-half of each zigzag winding neutralized the phase shift of the other half, the resulting line connection point being in phase with the 66-kv. system, so that these 66-kv. delta, zigzag 4-kv. star banks may be paralleled with

* Report of subcommittee on new developments, electrical apparatus committee, Engineering Section. G. A. Riley, chairman. K. B. Ayres, M. L. Baden, A. W. Copley, O. A. Gustafson, R. A. Hopkins, T. K. Lovell, S. P. Russell, C. E. Schnell, F. H. Searight, E. A. Sixtus, W. C. Smith, H. T. Sutcliffe.

[1] By H. L. Sampson, Southern California Edison Company Ltd., for the subcommittee on new developments, electrical apparatus committee.

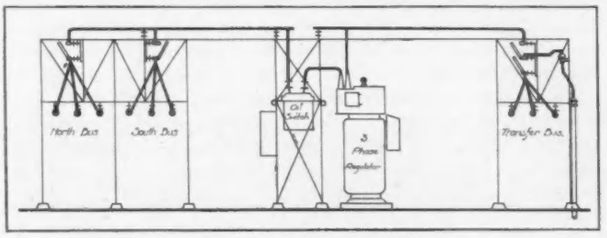

Fig. 3—Diagram of new type substation used by Southern California Edison Co. Ltd.

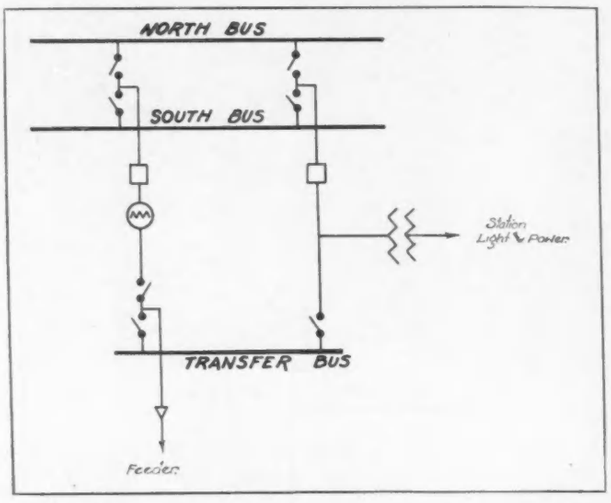

Fig. 4—Schematic one-line diagram showing one feeder and the bus-tie position

other stations which are fed from the intermediate voltage systems.

Fig. 1 illustrates at point (X) that lines cannot be paralleled because of being 30 deg. out of phase; Fig. 2 illustrates the zigzag transformer connections.

New Type Substation

This year the Edison company has made one outdoor 4-kv. substation installation of the pattern shown in Fig. 3. Fig. 4 is a schematic one-line diagram showing one feeder and the bus-tie position, of this station.

The bus-tie oil switch is used normally to carry the station light and power only, but may be used as an emergency pick-up, through the transfer bus, for any feeder, in case of regulator or switch failure. Any regulated feeder may be paralleled with any other regulated feeder through the transfer bus, using disconnects for making and breaking hot parallel. This is the normal method of shifting load from one feeder to another without interruption, for maintenance purposes. A new-type outdoor 4-kv. substation of the Southern California Edison Co. Ltd. is shown in Fig. 1 of the paper on voltage regulation in distribution substations. (See page 313.)

The following points of this design are worthy of mention:

1. All equipment very accessible.

2. Buses are not affected by arcs, if disconnects should be accidentally opened hot.

3. Minimum amount of equipment is permanently attached to line, and this is so located that it is out of the path of damage on account of other equipment failure.

4. A minimum amount of steel rack is required.

Discussion on New Developments[2]

Zigzag Grounding Transformer Installation

IN DECEMBER, 1930, a 3,650-kva. (one-minute rating), 33,000-volt (53.5 per cent impedance), 60-cycle, interconnected star, or "zigzag"-type grounding transformer was installed on the 33-kv. bus of one of our 100/33-kv. substations, in order to establish a neutral ground connection at this station and thereby provide a dependable means of utilizing protective ground relays on the 33-kv. distribution feeders out of this station.

The operation of this transformer has been satisfactory, although some difficulty has been experienced in switching the unit into service after removal for inspection. The difficulty referred to consisted of flashovers on one of the 33-kv. single-pole disconnects, through which it is tied to the station bus. This may have been due to a temporary ground on one of the 33-kv. feeders or to the breaking down of a lightning arrester gap, but nothing has ever been found which will definitely clear up the cause. Such flashovers have occurred on two or more switching occasions. If this disturbance continues, an oil circuit breaker will be provided as a means of connecting this transformer to the system.

A report on the experiences of other member companies with this type of transformer would therefore be welcomed.

"High-Speed" or "Quick-Response" Excitation Equipment for Synchronous Condensers

This company made use of high-speed excitation equipment for the first time when it installed a 5,000-kva. leading (2,500-kva. lagging), 2,400-volt, 900 r.p.m., three-phase, 60-cycle synchronous condenser at its El Centro substation in 1930. The main exciter, which is direct-connected to one end of the condenser shaft, is a 30-kw. 125-volt unit, and the "pilot" exciter, which is rated at 3½ kw. 125 volts, is mounted on the same end of the shaft as the main exciter and direct-connected to it. The type of regulator used on this machine is an AJ-11 exciter rheostatic voltage regulator.

With the above equipment, it is possible to obtain a voltage change of about 300 volts per sec. over the average range of required operation, as compared to about 70 volts per sec. when operated self-excited.

Subsequent synchronous condenser installations utilizing high-speed excitation, by means of "pilot" exciter, have also been made on our system at San Bernardino substation and Hoover Dam substation, during 1931.

The San Bernardino substation installation consists of a 15,000-kva. (leading and lagging), 6,900-volt, 900-r.p.m., 3-phase, 60-cycle condenser, equipped with an 80-kw., 125-volt direct-connected exciter and a 3-kw., 125-volt, direct-connected "pilot'" exciter. This machine is controlled by an AJ-22 exciter rheostatic voltage regulator, which combination of equipment makes it possible to obtain a "build-up" voltage of approximately 200 volts per sec. in the condenser field.

The Hoover Dam substation installation consists of two 7,500-kva. leading (3,750-kva. lagging), 2,400-volt, 900-r.p.m., 3-phase, 60-cycle condensers, each equipped with 45-kw. 125-volt direct-connected main exciter and 3-kw. 125-volt direct-connected "pilot" exciter. These machines are controlled by type-FA-4 voltage regulators. With this equipment it is possible to obtain a "build-up'" voltage of approximately 200 volts per sec. in the condenser field.

All of the above installations have given very satisfactory service so far.[1]

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[2] By M. L. Baden, The Southern Sierras Power Company, for the subcommittee on new developments, electrical apparatus committee.

[1] None of the so-called "super-excitation" installations has yet been made on our system.

Outdoor Synchronous Condenser Installations

To date this company has not made any outdoor synchronous condenser installations, but has given some preliminary consideration to utilizing such equipment at one or two locations on its system where future condenser capacity will probably be required.

Such studies have brought up the question as to whether it would not prove almost as satisfactory, and somewhat more economical (at the present time at least), to equip a standard inclosed-type indoor condenser with suitable weatherproof housing so as to be satisfactory for outdoor service. This housing would be fabricated from steel in such a manner that it could be very simply dismantled (either partially or wholly) for overhauling or repair work and could, if desired, be made large enough actually to allow room for attendants to enter either end of inclosure for inspection purposes. The cost of such a housing would be little more than that of a very small steel building of the same cubical contents.

Ultimately, when the demand for outdoor synchronous condenser equipment reaches the state where such equipment can be more or less standardized and the design and development cost reduced accordingly, it will no doubt prove economical to make use of standard outdoor-type condensers.

Use of the indoor-type condenser equipped with weatherproof housing for outdoor installations, referred to above, has the further advantage of allowing the utility occasionally to make certain desirable shifts of existing condenser equipment on its system to suit load-change conditions. In such instances, in the reinstallation of existing equipment it could readily be converted to outdoor type if desired.

Condenser auxiliaries, such as oil circuit breakers, autotransformers, etc., would preferably be of the outdoor type, while the automatic or semi-automatic control panels, together with relay equipment, would be installed in a small steel cube, if other building space were not available.

The Trend of Development of Electrical Apparatus Used by Central Stations[1]

IN THIS period of slow expansion of utility systems it is opportune to review the progress of design over a period of years with the idea of studying present system equipment and its possible economical replacement by later and more efficient apparatus. Such a review will do much to indicate, not only the probable obsolescence of old equipment, but also the possibilities that the future may have in store for us, influencing our idea of the obsolescence factor to be applied to apparatus now being manufactured or installed.

The determination of obsolescence factor on apparatus which is several years old is not difficult and involves only a study of the development since it was built. Increased efficiency, decreased weight or physical size, increased ratings and economy of operation can be rather definitely seen in past development. When we consider the future, we can only guess as to such matters, but a review of the past may be of assistance.

In this paper is presented information concerning past development of several major pieces of equipment. In many cases curves have been drawn with the idea of showing development trends.

Vertical Waterwheel Generators

The first curve (Fig. 1) shows the growth in the maximum ratings of vertical waterwheel generators built by one company over the 22-yr. period beginning with 1910. It indicates that the maximum rating has increased from 12,000 kva. to 67,000 kva.

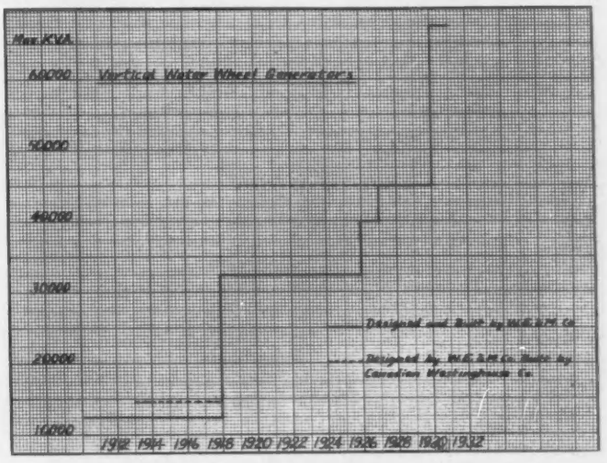


Fig. 1—Vertical waterwheel generators

At the same time that larger units have been developed, there has been a decrease in losses, as is shown by the curve in Fig. 2. The losses in present-day designs are only 70 per cent of the losses in machines built in 1910. The present-day losses on a large generator are about 2 per cent of the generator rating. How much further will it be economical to go in the reduction?

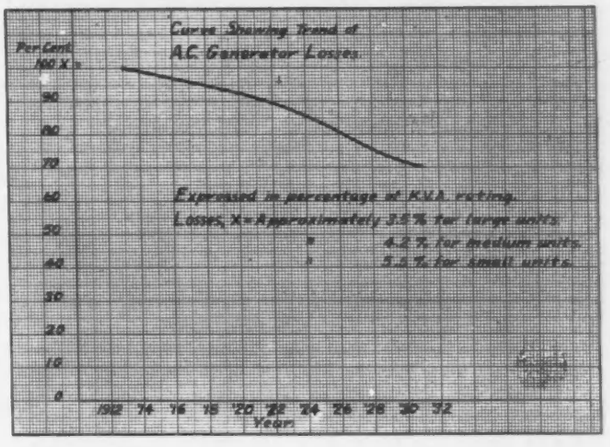


Fig. 2—Curve showing trend of a.c. generator losses

Synchronous Condensers

The curve in Fig. 3 indicates the growth in the maximum ratings of synchronous condensers over a 20-yr. period. The last ten years has been noticeably a time of increasing sizes. It is noteworthy that in this development, higher speeds have been a large factor, resulting in smaller physical size and weight for a given rating. The 15,000-kva. condenser built in 1913 for the Pacific Light & Power Co. has a speed of 375 r.p.m. Ten years ago this size unit was designed for 600 r.p.m. The present design of 15,000-kva. condensers has a speed of 900 r.p.m.

The progress of design can also be seen by the curve shown in Fig. 4. This shows that losses have decreased 40 per cent in the last twenty years. The recent introduction of hydrogen-cooling for synchronous condensers will result in further decreases in losses or a decrease in the physical size and weight of the units.

Outdoor units have been proved to be practicable, and

[1] By A. W. Copley for the subcommittee on new developments, electrical apparatus committee.

their use results in considerable saving in building costs in new installations. Such units may be either of the air-cooled or the hydrogen-cooled type.

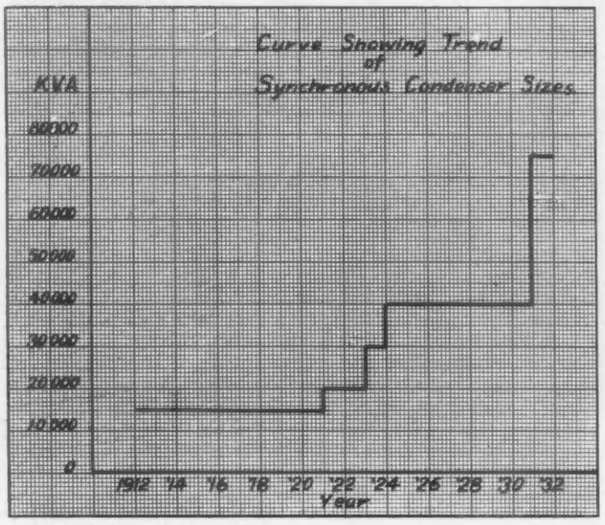


Fig. 3—Curve showing trend of synchronous condenser sizes

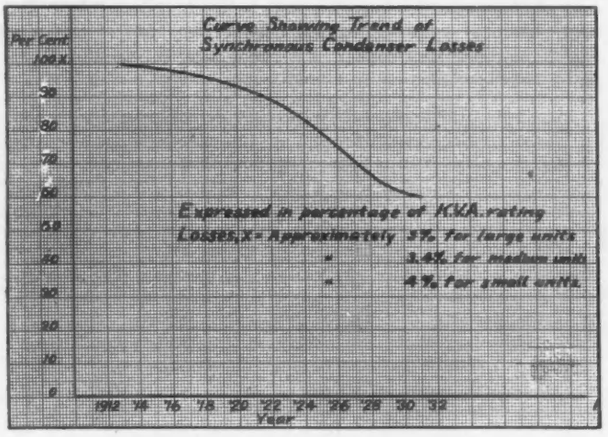

Curve Showing Trend of Synchronous Condenser Losses
Per Cent
Expressed in percentage of KVA. rating
Losses, X= Approximately 3% for large units
3.4% for medium units
4% for small units.
Year

Fig. 4—Curve showing trend of synchronous condenser losses

Synchronous Converters

Fig. 5 shows the progress in the design of synchronous converters. The introduction of commutating poles and increase in the peripheral speed of commutators are the factors contributing most to the building of larger sizes than were considered possible 25 years ago.

The increased efficiency of converters is shown by the curve in Fig. 6. There is also shown a curve of weight, indicating the trend during the last twenty years. These curves cover a single rating of 2,000 kw., but are typical for any given rating.

Power Transformers

Fig. 7 gives data in regard to the growth in the maximum ratings of power transformers over a 40-yr. period. The voltage rating naturally follows closely the curve of transmission-line voltage, although in a few cases it is a little ahead of this because of the building of transformers in anticipation of the higher line voltage, to be used temporarily at the lower voltage in effect at the time.

On the curves showing maximum kva. ratings, the effect of the addition of radiators to self-cooled units is quite apparent, and more recently the use of air blast on the radiators has resulted in a marked rise in the maximum capacities.

The increase in transformer efficiency is shown by the curve on Fig. 8, which is plotted from data on the designs of a standard single-phase 60-cycle 132,000-volt unit. Trans-

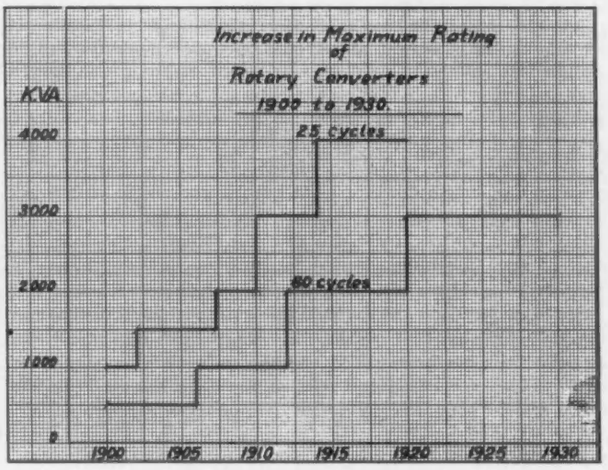


Fig. 5—Increase in maximum rating of rotary converters

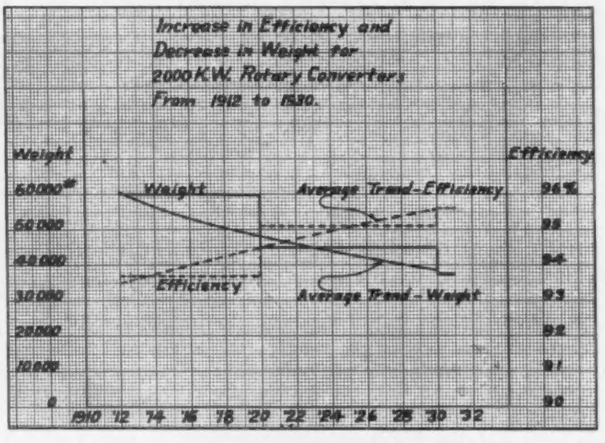

Increase in Efficiency and Decrease in Weight for 2000 K.W. Rotary Converters From 1912 to 1930.
Weight
Efficiency
Weight
Average Trend - Efficiency
Efficiency
Average Trend - Weight

Fig. 6—Increase in efficiency and decrease in weight for 2,000-kw. rotary converters

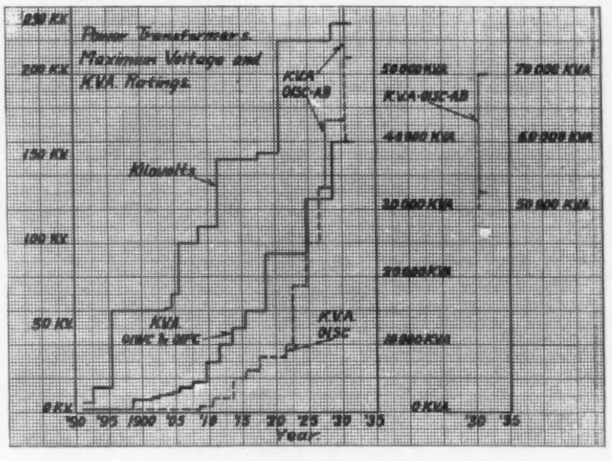


Fig. 7—Power transformers, maximum voltage and kva. ratings

formers have been designed and built with higher efficiency than shown on this curve, but in general they should be considered as special. The curve indicates the trend for what might be considered a standard well-balanced and economical design.

Improvements in transformers which cannot be shown by curves have been important. The introduction of expansion tanks, applied so as to keep the transformers full of oil and air away from contact with hot oil, was an important step, but not an unmixed blessing, for a good feature of older transformers was the cushion formed by the air above the oil,

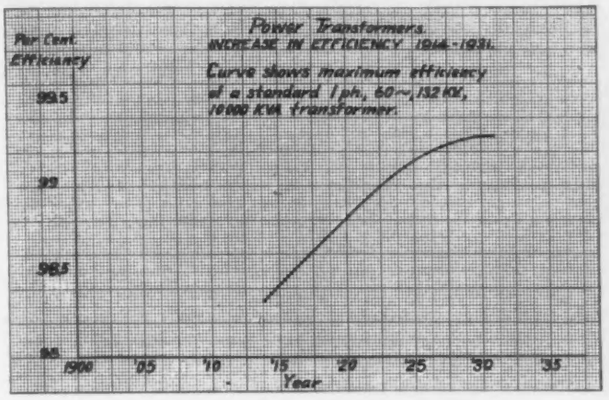


Fig. 8—Increase in efficiency of power transformers

which gave a certain amount of protection to the tank if internal arcing occurred. This advantage of the older construction, together with the elimination of the disadvantages of having hot oil in contact with air and the presence of an explosive mixture above the oil, was obtained by the inertaire equipment. This results in even better sludge protection for the oil than is obtained in any other manner, a positive gas cushion and a non-explosive mixture of gas above the oil. The efficiency of the equipment has been well demonstrated in instances of transformer breakdown. Oil is not thrown out of the tank, no explosion occurs above the oil level, and the tank is left intact.

More recently further development of transformers have been made for the purpose of eliminating breakdown of the winding during lightning surges. The latest development is the surge-proof transformer. In this design cognizance has been taken of the fact that creepage distances over insulation do not have the same impulse ratio as puncture distances. The elimination of all creepage distances in the insulation by the new design has resulted in the building of units which are self-protecting against surges. Two 110,000-volt units were built, to obtain direct proof of the efficacy of the new design. Both had the same 60-cycle dielectric strength. One had the older type of insulation, the second had the new type, which is a simple modification of the old. Both were tested to destruction with increasing surges from a lightning generator. The one built according to the new design withstood practically twice the surge voltage at which the other one broke down.

A 42,000-kva. 220,000-volt unit built with the surge-proof design was subjected to the most severe surges that could be obtained from a 3,000,000-volt lightning generator of the highest capacity that has ever been built, and the unit was undamaged. The bushing flashed over at 2¼-million volts, while the surge was rising at the rate of 3-million volts per micro-second. Surge-proof transformers are now commercial and represent a most important advance in design.

Distribution Transformers

The development of distribution transformers over a period of years has been aimed at the production of more economical units and the balancing of first costs against operating costs. The curves in Fig. 9 indicate that losses have not been greatly changed during the last ten years, but quite a marked change in weight is seen. These curves are for a single-phase transformer of 25-kva. rating, 2,300/115/230-volt, 60-cycle. Quite early in the development of distribution transformers it was realized that a low copper loss was less important than low iron loss and from a study of the cycle of operation of the average transformer, an economical ratio between copper loss and iron loss was determined, which is being maintained. The economical ratio will change only

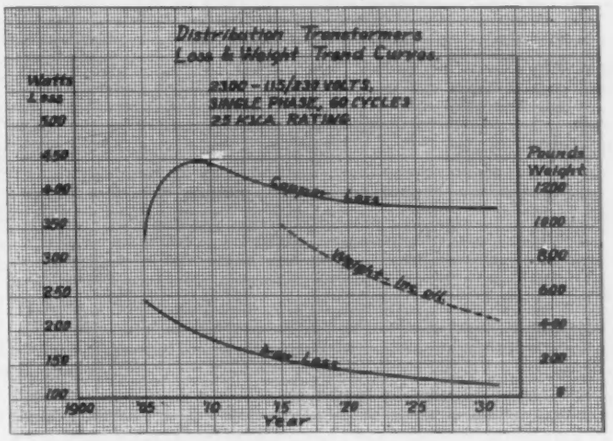


Fig. 9—Loss and weight trend curves, distribution transformers

when the average or representative cycle of loading changes, and it is not probable that the operation cycle will be very greatly altered in the future from what it has been in the past. The decrease in weight has been brought about not only by the use of better materials but also by more efficient design.

Induction Regulators

Fig. 10 indicates the growth in the maximum rating of induction regulators during the past 30 years. The increase in desirable characteristics of induction regulators is difficult to show by means of curves, because these characteristics involve the mechanical as well as the electrical design,

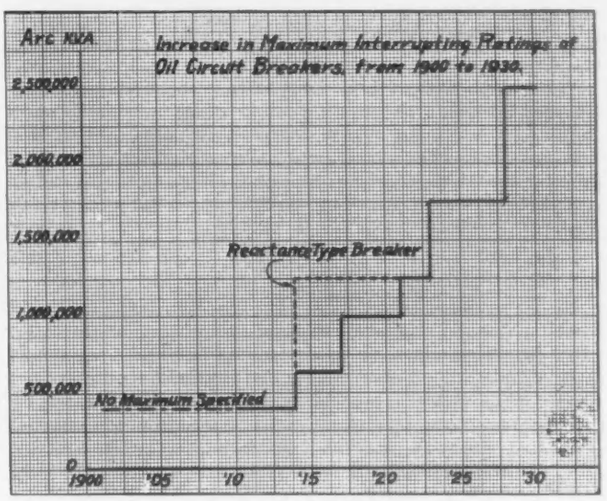


Fig. 10—Increase in maximum interrupting ratings of oil circuit breakers

and also because of convenience of installation and maintenance. The most recent development has been the regulator with all parts immersed in oil, with the exception of the operating relays which are mounted in a weatherproof cabinet on the side of the regulator, resulting in a simple, self-contained, quiet piece of apparatus, representing a great advance over the designs of some years ago, which had relays mounted on separate panels and the motor, brake, wormgear and limit switches exposed on the top of the regulator.

Oil Circuit Breakers

The characteristics of oil circuit breakers, with the exception of interrupting capacity rating, are quite difficult to show by means of curves. The growth in interrupting capacity ratings over the past 30 years is shown in the curve on Fig. 11.

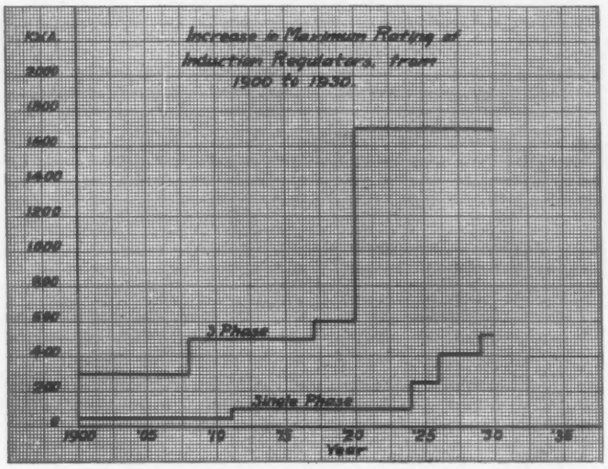


Fig. 11—Increase in maximum rating of induction regulators

Oil circuit breakers first became commercial around the beginning of the present century. From about the year 1900 to 1905, practically all transmission and distribution was at low voltages. The breakers were of very light construction, and anything which would hold oil and would be large enough to provide insulation clearances, and mechanical strength to handle and operate the contacts, was usually sufficient to provide ample interrupting capacity. At this time all loads were light, mechanical shock was small, porcelain insulation with wood tank-liners, barriers, and lift-rods, was entirely satisfactory.

Between the years 1905 and 1910, transmission voltages increased, because of extension of line, and new features of construction. During this period no new features of importance were added to the breaker, but because of increase in line voltage and some increase in interrupting capacity required, it was necessary to replace numbers of the breakers supplied in the five to ten years preceding.

From 1910 to 1916, voltage increase on systems was small, but power concentrations began to increase. About this time, it was found that the flat-side, open-top tanks no longer would withstand the pressure incident to short-circuit interruptions on the heavier systems. As a result, we found tanks bulged, tops broken, insulators broken, etc. This condition brought about a revision of design ideas, in which we first saw the advent of the round tanks, which would stand the shock, and pressures from the heavier short-circuit currents. At the same time cast-steel parts began to replace cast-iron parts. At this time, for reasons of economy and safety, the outdoor circuit breaker began its reign of popularity.

From 1916 to 1920 little was done in the design of oil circuit breakers, because of war-time pressure.

From 1920 to 1925, further extension of heavy construction with a view to reduction of oil and flame expulsion, and a recognition of the hazard to life and property, made necessary considerable modification in design. In doing this work, the strength of parts was increased, the contact speed, both opening and closing, was increased, and considerable development was carried out along the lines of obtaining improved interruption by the use of high-speed contacts. All of this was successful in again increasing the capacity of the breakers to the point where they were much more capable of handling the service imposed upon them by the ever-increasing systems.

From 1925 to date, further concentration caused demands from operating companies for breakers to clear faults without disrupting service in large areas, higher speed of fault-clearing, possibilities of synchronizing more easily, uniform and more reliable clearing of trouble to accommodate relaying of intricate connections. This, together with demands imposed upon the utilities to guarantee a continuity of service impossible under older operating conditions, made necessary further development in the circuit breaker field. As a result of these demands, between the years 1925 and the present date, the design of breakers has been almost completely revised. During this period we have brought out the "de-ion" air-breaker and the "de-ion grid" oil breaker.

A reviewing of the foregoing would seem to indicate that approximately every five years there have been necessary radical improvements in the design of circuit breakers. In each case, breakers have been provided which were adequate to meet the demands of the systems in which they were installed. The growth of the system has, however, been so rapid that, within a short time, it has entirely outgrown the capacity of the circuit-breaking apparatus.

Networks

During the past ten years apparatus has been developed which makes possible the use of low-voltage networks. The network protector has been the key to the situation. Six years ago this consisted of a circuit breaker with several relays, mounted in a cabinet or on a panel arranged to disconnect a distribution transformer automatically when the feeder connected to that transformer was opened at the substation end. The fundamental idea of the network protector has not been changed but development has taken place, which has simplified it in a very marked way, the more recent developments being along the line of combination units comprising the transformer, the network protector proper, disconnecting and grounding switches. The trend has been toward completely submersible outfits because of the use of the units in manholes. These combination units are the preferred outfits at present. Their development has been incidental to the development of the network system proper but without them the network system itself is greatly handicapped in its feasibility.

Development in other lines of apparatus has followed trends similar to those which have been illustrated. The items which have been specifically included here probably cover a wide enough range to allow rather general conclusions to be reached as to the obsolescence of apparatus and the desirability of its replacement after a period of years, because of the higher efficiency of operating economy and reliability that can be obtained from apparatus of more modern design. From a theoretical standpoint, there is still room for considerable improvement in efficiency in some lines. In other lines such as large generators and transformers, the economical limits of efficiency are probably being very closely reached. Improvements in such apparatus therefore must take the form of decreasing unit weights and sizes and increasing ratings, rather than increased efficiency.

Utilization of Automatic Throwover Apparatus for Street Vaults and Customers' Substations Where Automatic Transfer of Load to a Standby Circuit is Required[4]

History of Development

IT became necessary for the Los Angeles Gas and Electric Corp. some five or six years ago to provide certain customers with an automatic throwover switch, which would transfer load in case of an emergency to a standby circuit.

The company's practice up to this time had been to furnish important customers requiring 300 kw. or 400 kw. and over with a class (B) substation, with two incoming lines terminating in oil circuit breakers, with manual control. In case of trouble to one of these lines, it was the practice to depend on the customer's engineer to switch the load to the other line and thus restore service. This plan was fairly satisfactory, but cases developed where the engineer was not available at times of trouble, with the result that the customers would be without service for from five to thirty minutes, before someone could be found to operate switches and restore service. Also, through changes in the customer's personnel, the man in charge would not be familiar with the switching arrangement and would fail to act properly in opening and closing the correct switches. On certain jobs, such as important hospitals and theaters, the consulting electrical engineer would specify that automatic throwover equipment be furnished. All these factors, as heretofore mentioned, caused the corporation to start the use of automatic throwover switches for important customers requiring the best type of service.

Development of Apparatus

The type of automatic throwover first used by the company for this class of service was a standard contactor-controlled type of throwover. Seven installations of the above type were made during the years 1925 to 1930, but they did not entirely give the desired results, due to the fact that this type had a very low interrupting capacity and other objectionable features. On account of the lack of overcurrent protection afforded in this throwover, due to low interrupting capacity, additional oil circuit breakers were required to give proper protection to the transformer bank and services back to the switchboard. This, in turn, added to the number of disconnect switches and required more room space and caused a rather complicated switching arrangement. In order to improve upon the above conditions and to provide more compact and safer equipment and at the same time a neater general appearance, the Los Angeles Gas and Electric Corp. started to develop an automatic throwover device which would be more suited to the actual conditions demanded.

Types of Apparatus Required

In developing automatic throwover apparatus it was found that two distinct types of apparatus were required to cover existing conditions. One type was needed to take care of a transformer street-vault, where space in the building for transformers and switching equipment was not available, and automatic overload protection not essential. The other type was required to take care of a customer's substation with full automatic overcurrent protection, easily accessible to the operating engineer.

[4] By C. D. Bidwell, Los Angeles Gas and Electric Corporation for the subcommittee on new developments, electrical apparatus committee.

Street-Vault Type of Throwover

It was found that a street-vault automatic throwover best suited for the conditions of the lines of the Los Angeles Gas and Electric Corp., must be of a very compact type, requiring little vault space and capable of being submerged under water. It should be able to open entirely a standard subway-type oil circuit breaker of low interrupting capacity, before closing the other oil circuit breaker, without paralleling the two circuits. The problem of protecting the transformers through automatic overload devices could not be considered, as it would require larger oil circuit breakers of proper interrupting capacity and other apparatus occupying

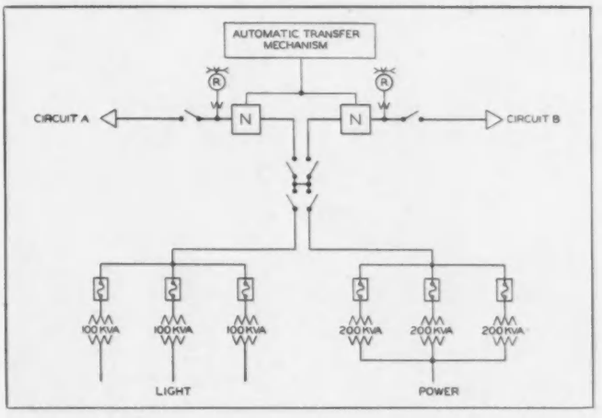


Fig. 1—Street vault with automatic throwover

too much space for a standard street-vault. Fig. 1 illustrates standard conditions as generally found in a street vault supplying power and light service to adjacent buildings, served with two incoming lines with an automatic transfer mechanism. The street-vault type of automatic throwover, as developed by the Los Angeles Gas and Electric Corp., consists of a submersible housing 32 in. wide, 33 in. high and 19 in. deep, of plate steel and angle-iron with welded seams and tested for 5 lb. air pressure. This housing contains a spring-operating mechanism with an a.c. motor for winding the spring, voltage relays, time-delay relay and necessary auxiliary and knife-switches. Two operating shafts project through the housing equipped with levers, which are arranged through a mechanical motion plate, so that one lever completes its full travel, opening one oil circuit breaker, before the other lever starts to close the other oil circuit breaker. This avoids paralleling the two circuits at any instant and prevents the carrying over of a short circuit on the line in trouble to the standby line. The voltage relays are arranged to give instantaneous transfer of the load to the standby line, when voltage drops below 30 per cent of normal. On return of voltage to the preferred line, a motor-driven time relay is energized, which transfers load back to the preferred line after a delay of two minutes. This allows time for system to return to normal conditions before a transfer is made.

Customer's Substation Type of Throwover

It was found that the type required for a customer's substation did not need to be of the submersible type, but should be inclosed for general safety and appearances. Therefore the automatic throwover developed was placed in a cubicle of sheet steel with angle-iron frame, 34x34x78 in., terminating each incoming line into the building and isolating each line from the other. This cubicle contains an oil circuit breaker with sufficient interrupting capacity to protect the transformers, necessary spring-operating mechanism to open and close the breaker, with an a.c. motor for winding

the spring, together with a six-pole gang-operated disconnect switch, interlocked with the oil circuit breaker to prevent opening under load and operated by an external handle. Current transformers and a potential transformer are located in the top of the cubicle. The potential transformer furnishes a power source for all tripping and closing operations, indicating lamps and operating motor for winding spring. Transite partitions and barriers are used in the cubicle to separate the different pieces of apparatus. Fig. 2 shows the front of the cubicle with all doors open and the six separate compartments for operating mechanism, oil circuit breaker, disconnect switch and current and potential transformers. Fig. 3 shows left hand side of cubicle with sheet steel removed. The cubicle is designed so that the top or sides can be removed to facilitate repairs or any other work, such as changing current transformers, etc.

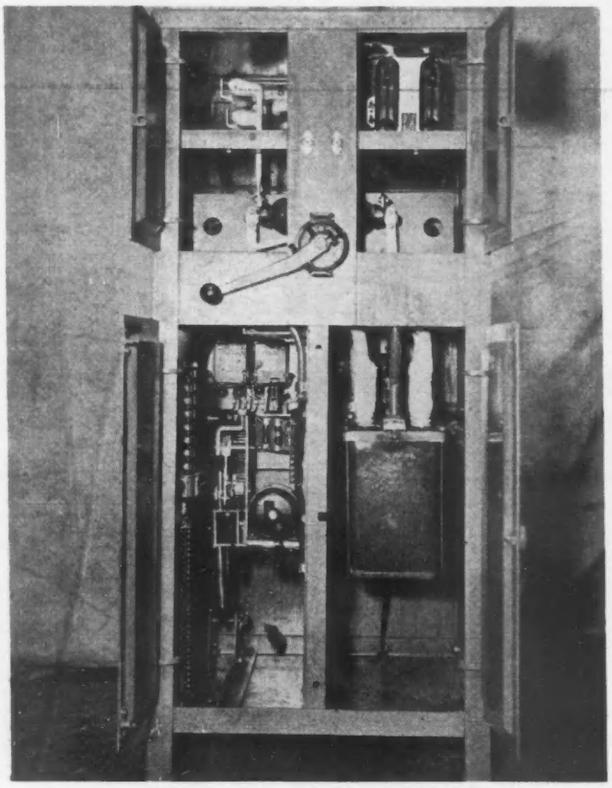


Fig. 2—Front of cubicle with all doors open

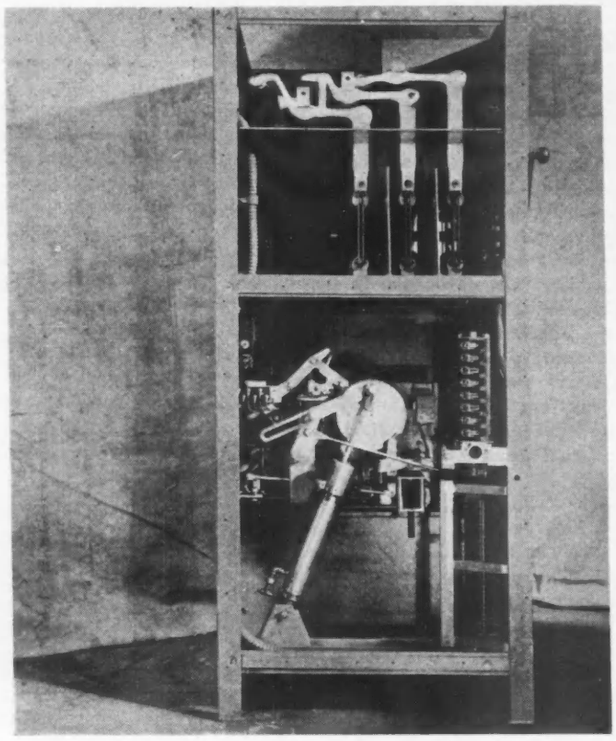


Fig. 3—Left hand side of cubicle with sheet steel removed

Type of Service Where the Cubicle Throwover Apparatus Is Adaptable

This type of apparatus is planned for customers requiring 300 kva. or over in either light or power, where the installation of two incoming lines is considered necessary to insure continuity of service, using one circuit as a standby—in other words, where the customer demands a type of service with the minimum of outages possible and where the outages, if they do occur, will be of the shortest duration. Large office buildings, theaters and hotels generally require this type of service and the amount of power and light used often exceeds the amount required by a small city of 20,000 inhabitants. It therefore can be readily seen that a substation is required for customers of this character, with the necessary protection for equipment and other features for restoring service, such as would be given a small city of this kind.

Description of Cubicle Setup For Different Types of Service

In jobs where lighting or power alone is being handled, two cubicles are used, each incoming line terminating in a cubicle with disconnect switches between the line and the oil circuit breaker, interlocked to prevent opening of disconnects under load. One oil circuit breaker is normally closed in one cubicle and the oil circuit breaker in the other is normally open. A failure of power will cause the cubicle connected to the preferred line to trip out and close the other cubicle on the standby line. A restoration of power on the line in trouble after two minutes will cause the standby cubicle to trip out and the other cubicle to close back on the preferred line. The setup is illustrated in Fig. 4.

In jobs where both lighting and power are being handled, three cubicles are used. The power is supplied through one cubicle and the light through another, the third cubicle acting as a tie between the light and power supply, closing in case of an outage on either of the two lines, and opening after two minutes, on the restoration of power on the line in trouble. (Figs. 5 and 6)

A small control panel with indicating lamps and control

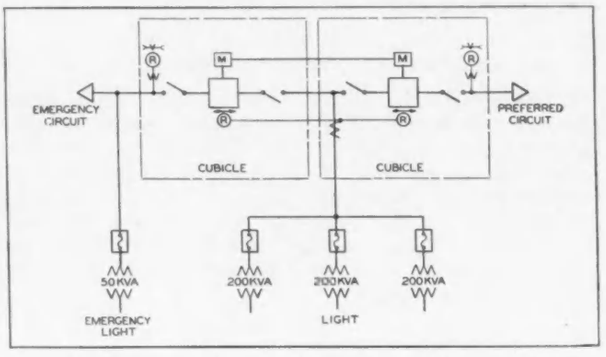


Fig. 4—Typical class B substation for lighting service

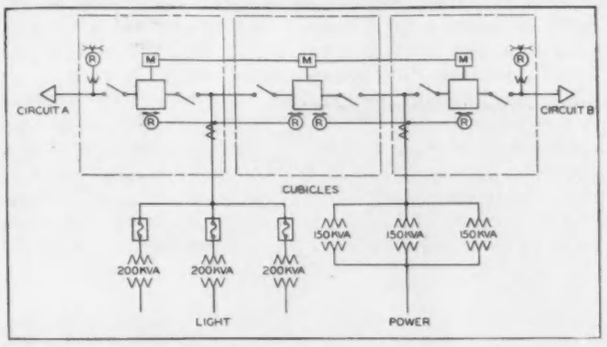


Fig. 5—Typical class B substation for light and power

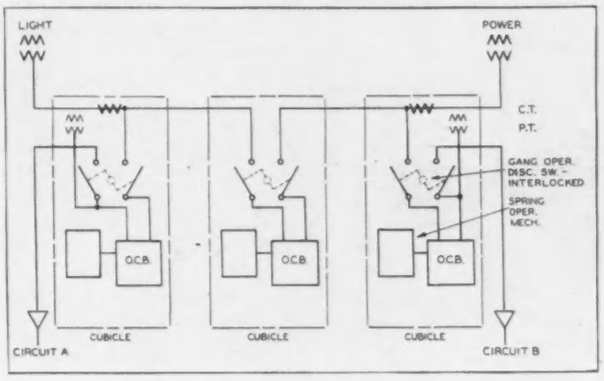


Fig. 6—Schematic diagram, class B substation with automatic throwover

switch is located at the customer's switchboard for remote control of cubicle and for disconnecting of automatic feature if so desired. No other apparatus is required in the customer's substation except the transformers, cubicles and two relay cabinets. All wiring, oil circuit breakers, current and potential transformers are inclosed in the cubicle. Control panel and relay panels are illustrated in Figs. 7 to 11. Fig. 11 shows control panel with control switch and indicating lamps located adjacent to customer's switchboard, where it can be readily seen at all times by the operating engineer and is easily accessible in times of trouble. In certain cases on important jobs, where the chief engineer has a private office, this panel is furnished in duplicate, without the control

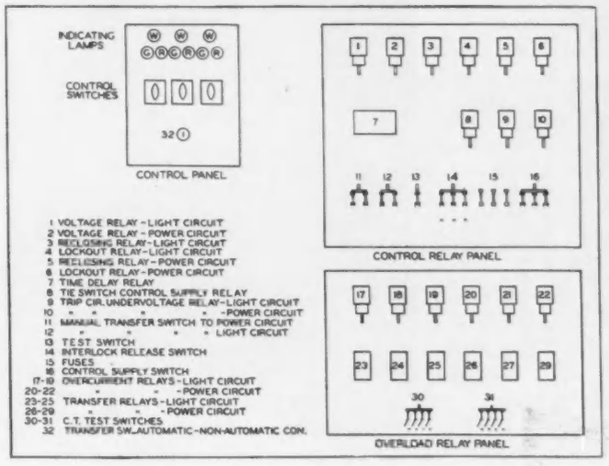

INDICATING LAMPS
CONTROL SWITCHES
32
CONTROL PANEL
CONTROL RELAY PANEL
OVERLOAD RELAY PANEL
1 VOLTAGE RELAY - LIGHT CIRCUIT
2 VOLTAGE RELAY - POWER CIRCUIT
3 RECLOSING RELAY - LIGHT CIRCUIT
4 LOCKOUT RELAY - LIGHT CIRCUIT
5 RECLOSING RELAY - POWER CIRCUIT
6 LOCKOUT RELAY - POWER CIRCUIT
7 TIME DELAY RELAY
8 TIE SWITCH CONTROL SUPPLY RELAY
9 TRIP CIR. UNDERVOLTAGE RELAY - LIGHT CIRCUIT
10 " " " " " - POWER CIRCUIT
11 MANUAL TRANSFER SWITCH TO POWER CIRCUIT
12 " " " " LIGHT CIRCUIT
13 TEST SWITCH
14 INTERLOCK RELEASE SWITCH
15 FUSES
16 CONTROL SUPPLY SWITCH
17-19 OVERCURRENT RELAYS - LIGHT CIRCUIT
20-22 " " " - POWER CIRCUIT
23-25 TRANSFER RELAYS - LIGHT CIRCUIT
26-29 " " " - POWER CIRCUIT
30-31 C.T. TEST SWITCHES
32 TRANSFER SW. AUTOMATIC - NON-AUTOMATIC CON.

Fig. 7—Automatic throwover control and relay panels, class B substation

switches, for indicating purposes only. Fig. 12 illustrates cubicles as installed in the customer's substation. Fig. 13 shows interior of cubicle where spring-operating mechanism is located and terminal block for incoming wires. All cubicles are wired internally exactly the same, so that they can be interchanged and still be used for different purposes, the control relay panel taking care of the different operations required.

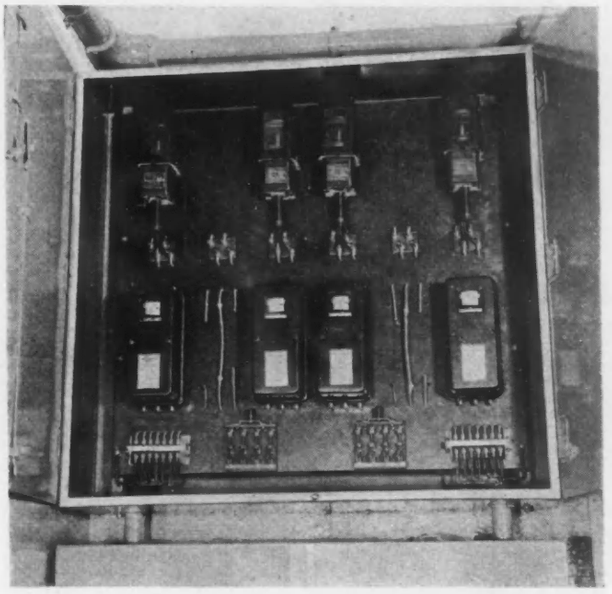


Fig. 8—Overload relay panel

Type of Lighting Service Furnished

It is customary to use three transformers in a lighting bank, connected in Y or closed delta across 4,000 volts or 2,400 volts on the primary side and providing the customer

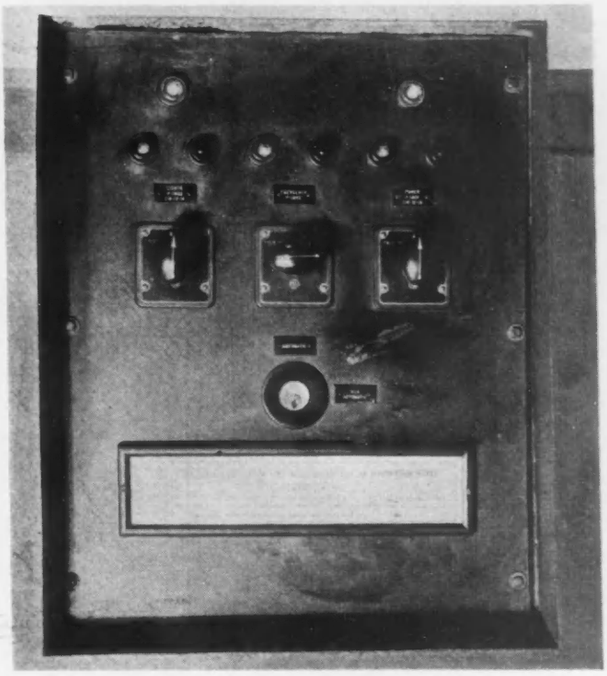


Fig. 9—Control panel

with three single-phase three-wire circuits, 110/220 volt, on the secondary side. The customer's switchboard is then divided into three separate groups of feeder switches, each group supplied by an individual transformer in the bank.

Description of Cubicle Operation From Overcurrent

A short circuit on either the power or lighting bank will cause the oil circuit breaker feeding the bank to open and try to reclose after a lapse of two seconds. (See Fig. 14.) In case the short circuit still remains, the breaker will open and lock out. The overcurrent relay used is a standard type, with inverse time limit and closing contacts. The relay is normally in series with a current transformer and a transfer relay. In case of overcurrent, the contacts of the relay are closed, operating the transfer relay, which in turn forces all current through the trip coil, insuring positive tripping. A lockout relay, in series with the overcurrent relay with electric reset, is used to prevent constant reclosures after a short circuit, as the automatic setup naturally tends to close the breaker if the voltage is maintained on incoming line. The reset of this relay is accomplished with an extra point on the control switch at the control panel, so that the reclosure of breaker from the control handle, after trouble has been removed, resets the lockout relay at one operation, namely closing the breaker. One automatic reclosure after a short circuit is obtained by having the lockout relay normally short-circuited by an extra point in the auxiliary switch for the spring-operating mechanism. Under normal conditions, the spring is wound and the lockout relay short-circuited, whereas during the winding of the spring, which requires

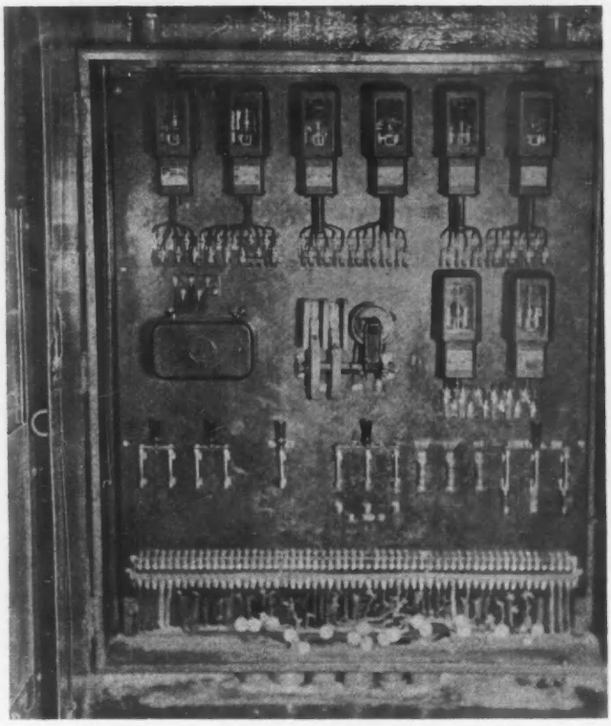


Fig. 10—Control relay panel

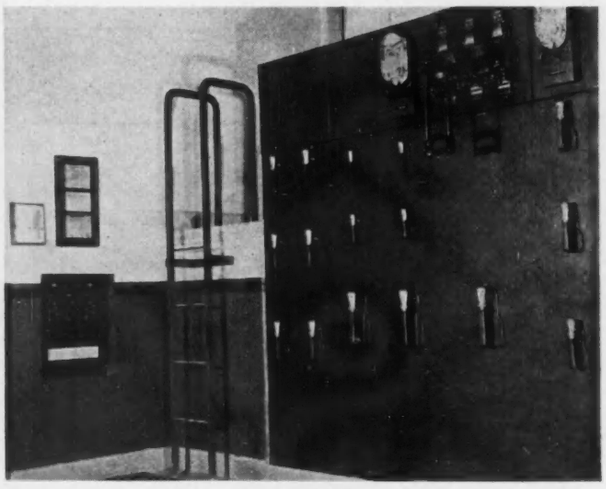


Fig. 11—Control panel with control switch and indicating lamps, located adjacent to customer's switchboard

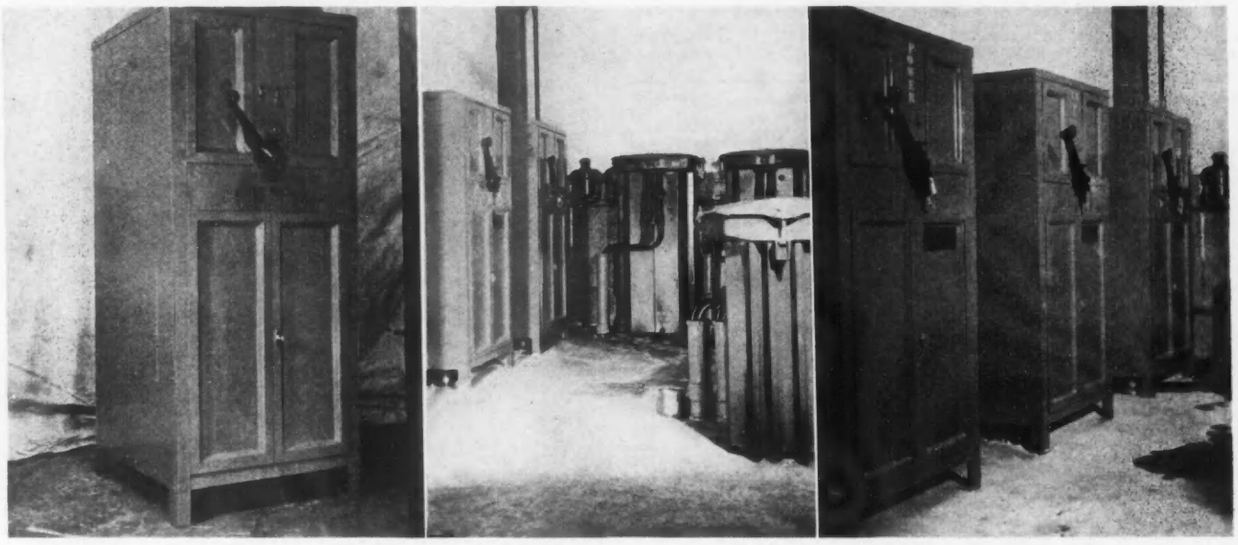


Fig. 12—Cubicles installed in customers' substations

sixteen seconds, the lockout relay is not short-circuited, and a tripping operation after the first reclosure, only two seconds later, will therefore cause relay to lock out.

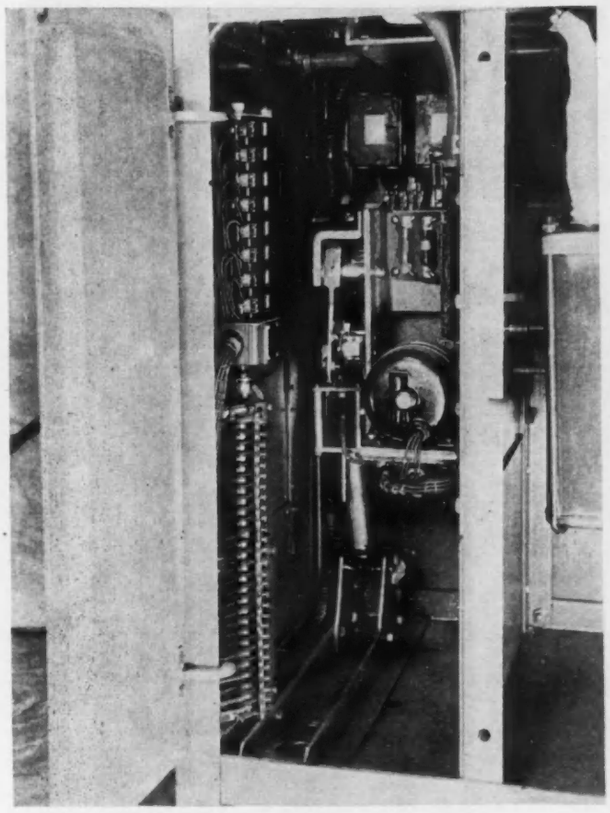


Fig. 13—Interior of cubicle where spring-operating mechanism is located and terminal block for incoming wires

Description of Cubicle Operation From Lack of Voltage on One Line

The lack of voltage on circuit (B), Fig. 14, causes a voltage relay to drop out, which in turn causes the voltage in circuit (A) to trip the breaker out on circuit (B) in trouble, this in turn closing the tie breaker. After power has been restored on circuit (B), a motor-operated time-delay relay is energized, which is set with a two-minute delay, tripping out the tie-breaker and in turn reclosing the circuit (B) breaker. An undervoltage relay is introduced into the tripping circuit of each incoming line breaker, which is not energized until the voltage relay on the line in trouble drops out. This undervoltage relay picks up at 80 per cent of normal voltage and prevents the operation of the trip coil, unless voltage is sufficient to obtain positive tripping, as the trip coil is designed to give positive tripping on 50 per cent of normal voltage, or 60 volts, which is less than the pick-up value of the undervoltage relay. It was found that in attempting a transfer under low-voltage conditions, the plunger in the trip coil would rise up without sufficient force to trip the breaker and the effect of a hammer blow would be lost entirely, the plunger merely staying up on return to normal voltage, without tripping the breaker. The addition of the undervoltage relay insures positive tripping at all times, without regard to low-voltage conditions on the system at time of trouble, and prevents any failure of the automatic throwover to act due to lack of proper voltage. The breaker is closed by means of a spring-operating mechanism wound by a 1/6-hp. single-phase motor, obtaining current from the same potential transformer used to perform the relay operations.

Advantages of This Type of Apparatus Over Other Types on the Market

It was found that, with the standard type of throwover, considerable more apparatus was required, as the throwover did not provide overload protection and oil circuit breakers and extra disconnect switches had to be used as well. With a cubicle-type of installation, a much neater, more compact and safer job could be done, therefore requiring less room space. The use of standard motor mechanisms, centrifugal-type, for this purpose was also tried on several jobs, but their action is much slower in making a transfer, than with a spring-operated mechanism. This causes the lights to go out entirely and is more liable to allow the low-voltage release attachment on motors to drop out, causing the customer's motors to shut down. Low voltage with the motor mechanism is more liable to cause trouble in closing and latching the breaker, whereas low voltage has no effect on closing with a spring. Also, the motor mechanism requires a 1½-kw. transformer on each circuit to operate it, together with oil fuse cutouts, while the spring-operating mechanism operates from a potential transformer alone. Automatic reclosure is more easily accomplished with a spring-operating device without expensive relays. From our experiences, we feel that the spring-operating mechanism is best adapted for automatic throwover purposes.

Cost of Installations and General Results Obtained

The cubicle type of automatic throwover costs about the same as other types and in some cases slightly less; therefore, considering the many advantages gained and the much better general appearance of the installation, we believe their use is warranted from a cost standpoint. This company has to date four installations of this type, which so far have given the customer excellent service and have proved very satisfactory.

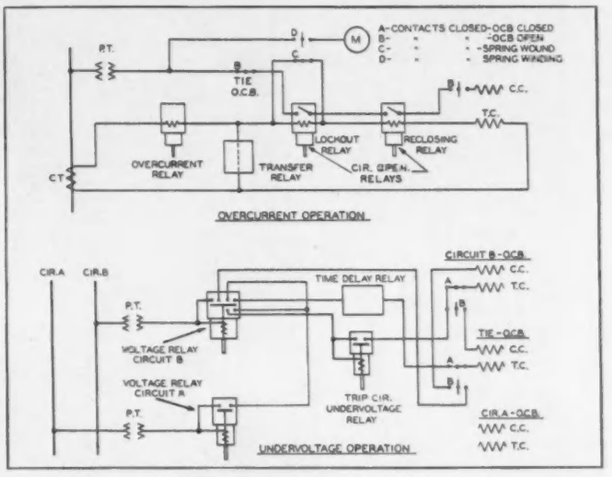
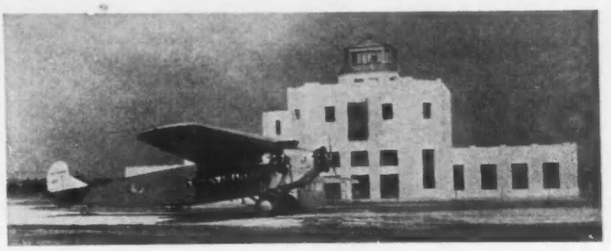
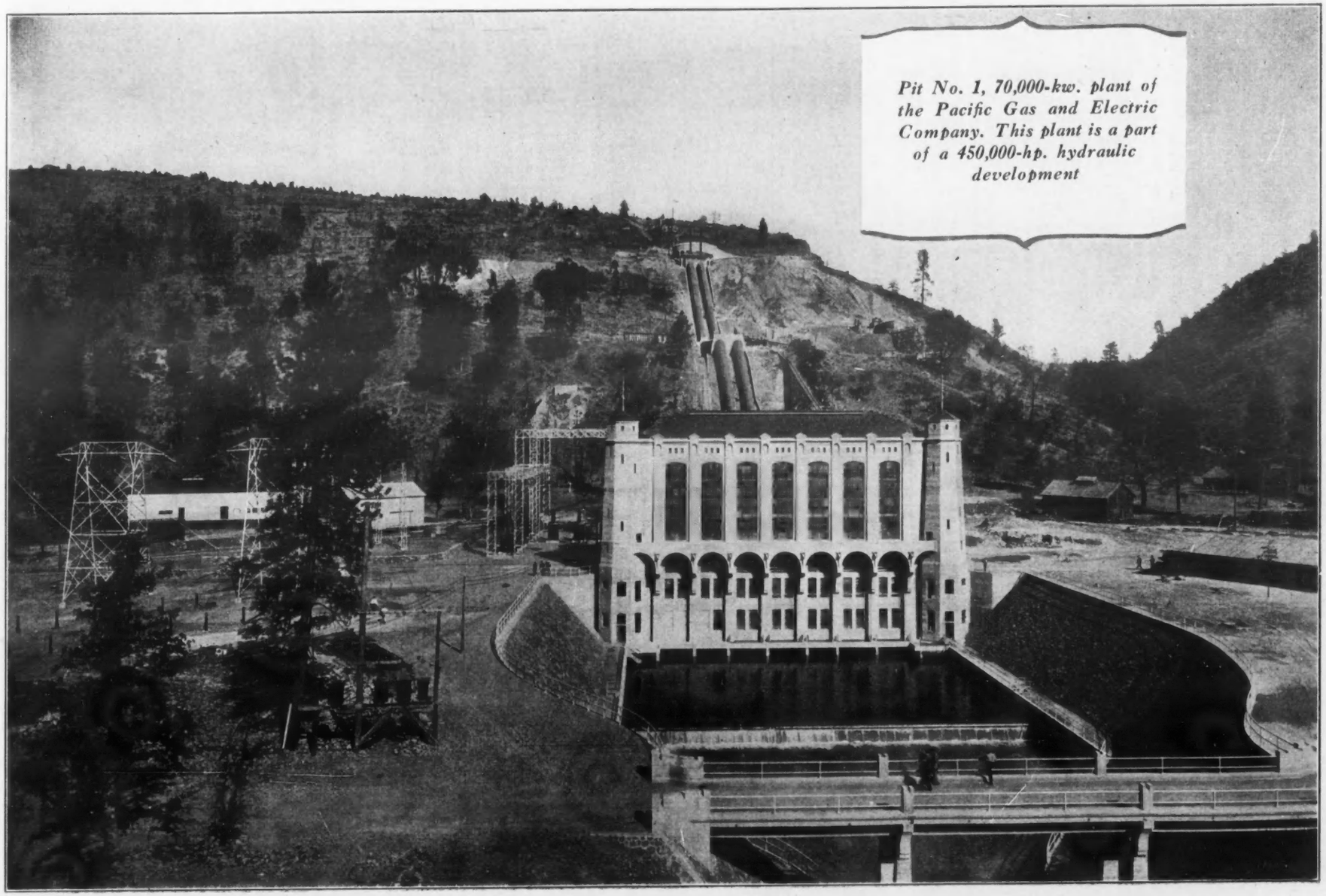


Fig. 14—Automatic throwover—schematic diagram of overcurrent and undervoltage operations





Pit No. 1, 70,000-kw. plant of the Pacific Gas and Electric Company. This plant is a part of a 450,000-hp. hydraulic development

FOREIGN SYSTEMS COORDINATION COMMITTEE REPORTS[1]

*Common Primary and Secondary Grounded Neutral**

The activities of this subcommittee during the Association year have been directed toward bringing the matter to a conclusion. The final cost figures on the Chico cutover were received and the report covering the preliminary tests and the results attained during the trial period was completed during the last months of 1931. The proposed amendments to General Order No. 64A to permit the use of a common primary and secondary grounded neutral wire on distribution systems of 5,000 volts or less were discussed with the engineers of the Railroad Commission at a number of meetings during the year and two small changes in wording in the practices were agreed to. In accordance with a resolution passed at the San Francisco meeting of the foreign systems coordination committee in September, 1931, and approved by the executive committee, a formal application was filed with the California Railroad Commission by Pacific Gas and Electric Company, the other power companies represented on the subcommittee joining in the application. The hearing on this application, first set for December 31, 1931, was reset from time to time, and finally held on March 24, 1932. The commission's decision, dated Apr. 4, 1932, was favorable, the use of a neutral wire common to primary and secondary being permitted under certain construction rules which are to be set forth in a supplement to General Order No. 64A. The Practices mutually agreed upon by parties to the proceeding are recognized as subject to revision by similar mutual agreement of all interested parties, notice of any revisions being required for the commission's files. The decision marks the culmination of a cooperative effort between the power and communication companies of California, which has resulted in better understanding of the mutual problems involved.

The report of the commission, first presented June 19, 1930, and revised to November 25, 1931, summarizes the considerations which led to the agitation of the matter in California, and outlines the results of the studies conducted, the inductive efforts and the savings effected. It will be noted that the savings are in copper costs, and thus should be viewed in their true relation to distribution capital. The report is presented here, with minor condensations and omissions of matter not now pertinent.

Certain practices were agreed upon which are applicable in urban areas to four-wire overhead power distribution systems, of voltages of 5,000 or less, with common primary and secondary grounded neutral, or with multigrounded neutral and telephone exchange plant serving the same area through aerial cables or wires.

Practices Applicable in Urban Areas to Four-Wire Overhead Power Distribution Systems of Voltages of 5,000 or Less With Common Primary and Secondary Grounded Neutral or With Multigrounded Neutral and Telephone Exchange Plant Serving the Same Territory Through Aerial Cables or Wires

THE practices outlined below are intended to be applicable to the construction of a new plant or in the reconstruction of an existing plant.

The studies on which these practices are based were concerned specifically with 4-kv. overhead distribution lines and with telephone exchange lines principally in cables in urban areas. Hence these practices are directly applicable to such cases.

The practices are not intended to be applied to other power distribution lines nor to long open-wire telephone lines, nor to telegraph lines, without further study which will be undertaken in connection with specific cases or otherwise as found necessary and desirable.

The benefits of certain power distribution practices, and of certain measures applicable to the telephone plant in coordinating the systems, are recognized in these practices.

1. Cooperative Planning of Routes

Arrangements shall be set up between the telephone and power utilities concerned providing for cooperative planning in the layout of new, or the reconstruction of existing, aerial plants when the power system is, or is to be changed to, a common neutral or other multigrounded neutral system, so far as may be necessary from the standpoint of good coordination. Among the measures found to be effective in noise reduction or prevention may be mentioned undergrounding, routing main lines over alternate routes, sectionalizing exposures, feeding in two directions from underground risers, etc.

2. Cooperative Planning of Facilities

In new areas or extensions of existing areas to be supplied by, or in areas to be changed over to, the common neutral or other multigrounded neutral system, due consideration should be given as far in advance as possible to the selection of both telephone and power equipment which is to serve the areas, and to measures that may be applied in order that satisfactory operation of both plants may be obtained in the most economical manner in line with the practices outlined herein.

3. Power Distribution Practices

3.1. Transformers in General—

Transformers should not be operated at voltages in excess of 110 per cent of normal rating. At normal rating, transformer exciting current and magnetic densities should be as low as practicable in accordance with generally recognized standards.

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[1] Geo. H. Hagar, Pacific Gas and Electric Company, chairman. C. M. Lindsley, The Southern Sierras Power Company, vice-chairman.
California Independent Telephone Association: T. J. Fleming.
General Electric Company: O. A. Gustafson, W. C. Smith.
Los Angeles Gas and Electric Corporation: C. B. Judson, E. R. Northmore.
Pacific Gas and Electric Company: C. C. Campbell, L. J. Corbett, R. R. Cowles, H. S. Lane.
Pacific Public Service Corporation: Charles Grunsky.
Pacific Radio Trades Association: G. H. Curtiss.
The Pacific Telephone & Telegraph Company: D. I. Cone, S. Rapp.
Radio Trade Association of Southern California: G. R. Walters.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow.
San Joaquin Light & Power Corporation: H. N. Kalb, R. E. Lake.
Sierra Pacific Power Company: V. D. Armstrong.
Southern California Edison Company Ltd.: R. B. Ashbrook, J. O. Binney, R. G. Boyles, F. B. Doolittle.
Southern California Telephone Company: G. E. Nott, M. A. Sawyer.
The Southern Sierras Power Company: E. Y. Porter, H. J. Schomberg.
Westinghouse Electric & Manufacturing Company: A. W. Copley, W. F. Grimes.

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* Report of subcommittee on common primary and secondary neutral, foreign systems coordination committee, Engineering Section. L. J. Corbett, chairman. K. B. Ayres, D. I. Cone, R. R. Cowles, T. J. Fleming, R. E. Northmore, G. E. Nott, E. Y. Porter.

3.2. At Substation Supplying the Distribution System—

Substation areas should be supplied by D-Y connected transformers, or Y-Y connected transformers with tertiary deltas of suitable size, or other arrangements which will effectively limit the amount of triple harmonics.

Banks of substation transformers should consist of three electrically like units, except in cases of emergency.

When an alternator or motor is to be operated with the neutral grounded and electrically connected on the distribution side of the station transformers or on the high-voltage side, if the transformers are connected Y/Y without tertiary delta, suitable means should be taken, either in the design or external to the machine, to reduce the triple harmonics as far as may be necessary and practicable.

3.3 On Lines of the Distribution System—

The distribution transformers used should be of standard design as manufactured and tested under current standards of the National Electrical Manufacturers Assn. and the American Institute of Electrical Engineers.

When transformers supplying three-phase loads are connected Y-D, the neutral point on the high-voltage side should be isolated, if the substation transformers are connected Y-Y. If the substation transformers are connected D-Y or Y-Y with tertiary delta, the neutral point of the load bank should, where practicable, be connected to the neutral wire.

3.4 Balance of Phases—

Every effort shall be made to keep the unbalance of phase currents in circuits involved in inductive exposures as small as practicable.

The current in single-phase branches involving one phase wire and neutral should, wherever practicable, be kept below 25 amp. and in no case should it exceed 50 amp.

When open-star branches feed loads connected between phase wires and neutral, the total resulting neutral current should not exceed the values specified for single-phase branches.

Successive single-phase or open-star taps should be arranged to secure the best practicable balance on the feeder. At the time of peak load, the unbalance at the substation should not be more than 50 amp., determined vectorially.

It is recognized that the length of exposure and the amount of unbalanced current may be controlling factors in the production of undesirable inductive effects in particular cases.

In long exposures or when it is necessary that single-phase loads requiring line currents in excess of the above limits be supplied, consideration should be given so far as may be necessary to good coordination, to the supply of loads across the phases or by a section having no grounds on the primary neutral wire within or beyond the exposure.

3.5 Continuous Neutral—

The neutral shall be a continuous metallic conductor of adequate conductivity on the same poles as the primary phase wires throughout the common neutral or multigrounded area.

It is recognized that grounding is for the purpose of stabilizing the neutral and not for use of the earth as a return conductor.

4. Telephone Practices

4.1 Cables—

Telephone cables of standard modern design and as well balanced as its practicable, both metallically and to ground, should be used.

In inductive exposures the cable sheath should be continuous and grounded at both ends of the exposure, where necessary and practicable. The ground connections should be of sufficiently low resistance to give effective shielding and should be made to a large underground cable system or to water pipes where available.

4.2 Central Office and Subscriber Set Equipment—

Central office cord circuits or other types of interconnecting units, and subscriber station sets, should be balanced as far as is practicable, in accordance with the standard modern practice. In special cases, consideration should be given, as far as necessary and practicable, to the use of high-impedance substation party-line ringers or other measures for reducing inductive effects.

5. Mutual Consideration

It is recognized that special cases may arise where satisfactory inductive coordination is not obtained after applying the proposed practices and that special cases may arise where load conditions on the power system are of unusual or intermittent character and the practices herein proposed cannot be carried out in a practicable manner. These cases should be considered individually, as they may arise, and suitable changes should be made in either or both of the systems to secure inductive coordination. Measures involving the greatest overall economy should be agreed upon to relieve the particular situation involved.

Report to Railroad Commission

FOR a number of years electric distribution has been accomplished in many localities by means of a three-phase system connected Y. At first the neutral point was grounded at the substation and a neutral wire was carried out with the primary phase wires, with no other ground connection, this constituting the uni-grounded system. The secondary wires were run on the three-wire system with the middle wire grounded, usually at every service and thus maintained at ground potential.

In order further to stabilize the neutral, many power companies have grounded the primary neutral wire at a number of locations, this constituting the multigrounded system. This arrangement has been necessary in areas served by underground cables, and has been extended to aerial systems in many other areas.

The carrying of two neutral wires, one for the primary and one for secondary circuits, both at ground potential but separated, has appeared a needless duplication, and in a number of localities they have been combined into a single wire. This has been done on various circuits and with varying arrangement of details, in the Province of Ontario; in Winnipeg, Manitoba; in Seattle, Wash.; in Portland, Ore.; in Omaha, Neb.; in New Orleans, La.; in Minneapolis, Minn., and elsewhere.

Certain California power companies affiliated in the Pacific Coast Electrical Assn., desiring to avail themselves of the economies to be obtained, wished the Railroad Commission of the state to modify its overhead line construction rules (General Order No. 64), then being revised, to permit the use of a common primary and secondary grounded neutral wire.

When the common-neutral system was first projected, the wider loop offered for primary unbalanced currents and for triple harmonics of the three-phase system suggested possible increased inductive effects on telephone systems whose circuits for many years had been brought into close proximity to the existing power distribution circuits by joint-pole practices, themselves a considerable economy to all concerned. Further, question had been raised in some quarters as to safety to persons if the common-neutral system were used. Because of this situation, the commission postponed definite action on the matter, pending receipt of sufficient information.

Tests to determine the technical features concerning the inductive effects of a common-neutral system had been con-

ducted in Minneapolis from 1924 to 1926*, but no complete studies had been made as to the economies involved. Therefore it was agreed among the representatives of the power and communication companies in California and the engineers of the Railroad Commission that such a study would be made before changes would be decided upon in the construction rules.

With the assistance of personnel from the American Telephone and Telegraph Co. and the National Electric Light Assn., this study was conducted from November, 1927, to December, 1928, and yielded data of considerable interest and value. It was found that the California methods of distribution differed somewhat from types used elsewhere in which the common neutral had been applied, and that, with proper coordination, noise conditions could be effectively controlled. The possible measures for that purpose on either system or on both systems for a given case varied so widely in nature and cost that any attempted statement of the relative economies meant little. In consequence, the outcome of the study was not the solution of a definite problem in economics, but a tentative set of "Trial Practices" agreed upon between the two classes of utilities to apply to the use of a common-neutral wire on four-wire distribution circuits of voltages not above 5,000 volts, and aerial telephone plant, principally in cable, serving the same urban areas. These were broadened to cover also new and reconstructed four-wire multigrounded neutral systems with the same voltage limit, as their inductive influence is practically the same. Representatives agreeing to the trial practices included personnel from seven power companies, two telephone companies associated with the American Telephone and Telegraph Co., and independent telephone companies in the California Independent Telephone Assn.

With these practices to govern the inductive coordination between the two classes of utilities more specifically than does the existing General Order No. 52, request was made of the Railroad Commission in April of 1929, for permission to use the common primary and secondary grounded neutral under the provisions outlined.

In its reply of May 13, 1929, the commission indicated that it would consider applications in particular cases where it was desired to change to the common-neutral system under the Trial Practices, and would lay down special construction rules to govern the installation. The commission set July 1, 1930, as the limiting date of a period for the trial of the common neutral under the Practices, and stated its views and understandings concerning the Trial Practices. These are considered in detail in the latter part of this report.

During the economic study, two areas were actually cut over from 2,300 volts delta to 4,000 volts Y, using the common-neutral system, under special permits from the commission and under agreements to change back to the delta system or to the two-neutral system in case bad noise conditions developed. These were the Alhambra area of the Southern California Edison Co. and the Substation No. 2 area of the Los Angeles Gas and Electric Corp.

Since the receipt of the commission's letter a number of other areas have been cut over to common neutral under similar permits and in accord with the Practices.

This report discusses the following major questions regarding the common-neutral system, from such information as is now at hand.

1. Is it safe as compared to distribution systems now permitted?
2. Is it workable without appreciable injury to telephone service?
3. Will its use result in a saving to the general public?
4. If so, are the savings such as to make it worth while?

The first is the responsibility of the power companies; the other three are joint matters between the power and communication interests.

* Minneapolis Joint Use Investigation. (Eng. Report No. 6, Joint D. & R. subcommittee, N.E.L.A. and Bell System.)

The power representatives on the subcommittee present the following discussion on the subject of the first question:

Safety Features

Nothing has happened during the trial period or since to indicate the existence of any particularly hazardous condition due to the use of the common neutral. It will be necessary therefore to look into the conditions that exist in now-accepted systems of distribution and compare them with conditions under the common-neutral system.

For the employee of the power company, there is no additional danger in having the primary neutral wire, frequently grounded, in the secondary neutral position. The secondary neutral wire is grounded at the transformer and is generally grounded at all services, so the common neutral is no different. There is even less hazard on the pole, for there is one less wire in the primary space.

As to the general public, the important consideration relative to safety in the supply of electric power is to avoid the possibility of raising the potential of the neutral conductor or water piping connected to it within a building to a dangerous voltage above better grounded conducting surfaces which may be within reach, either continuously under normal conditions, or temporarily because of a system fault. For safety of the employee of the water company, no high-voltage differences should arise in case of any operation on the water mains or service connections.

It is recognized that with the secondary neutral usually connected at every service to the water piping, and at each transformer to a water pipe or driven ground as required in California, the normal condition is equally safe whether the delta, uni-grounded Y, multigrounded Y or common-neutral Y primary system is employed. Therefore attention will be given here only to conditions under a single fault, with possible construction operations on the water piping.

In case of a power system fault, the voltage above ground of any part will be due to the amount of current flowing to ground through the resistance of the ground path. If the fault is close to a large substation where a large current can flow, a low resistance may permit a rather high voltage, but if the substation is small or the fault is remote from the station, where the additional line impedances further limit the current flow, a higher resistance to ground can exist for the same resulting voltage.

Power system relays and fuses open the circuit in a length of time which varies inversely with the amount of current flow, so a low resistance to ground is desirable, for it permits a greater current flow and therefore quicker severance and elimination of the dangerous condition.

The power system faults which would affect the safety situation are the following:

1. The dropping of a primary wire which contacts a secondary phase wire.
2. The dropping of a primary wire which contacts the secondary neutral wire.
3. A breakdown from primary to secondary winding in a transformer.
4. A break in the neutral wire.

The first three can all be treated under the typical case of a transformer fault, as they are closely alike electrically. The fourth will be considered separately.

Transformer Fault

Technologic Paper No. 108 of the United States Bureau of Standards discusses electric power system grounds, their resistances in various localities and many considerations concerning their installation and the matter of safety.

The only condition which is recognized as dangerous for a person working on the water piping, and, by inference, to any of the occupants of a building being served, is that in which a low-voltage circuit is grounded at a single point to

service pipes. Fig. 1 of this report is Fig. 19, page 100, of the above named publication, modified to be consistent with the other sketches presented here. If the water piping service is opened at (A), a fault (B) occurring in the transformer might cause a dangerous potential across the open joint at (A), or similarly, between the plumbing of the building considered and gas pipes or basement floors, radio ground wires, etc.

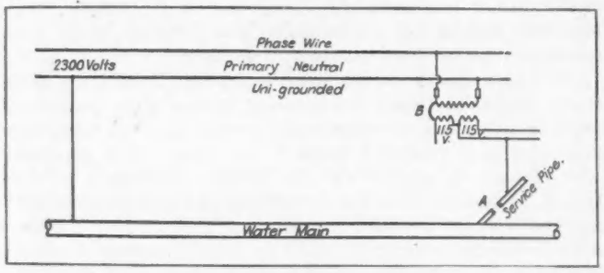


Fig. 1—Single service ground at end of uni-grounded primary run

In this state, it has been required that a single-phase secondary neutral be grounded at the transformer, and usually also within the building at each service. For comparison, this condition is represented in the sketch (Fig. 2). With a multiplicity of grounds, disconnecting the water service at (A) cannot result in a high potential across

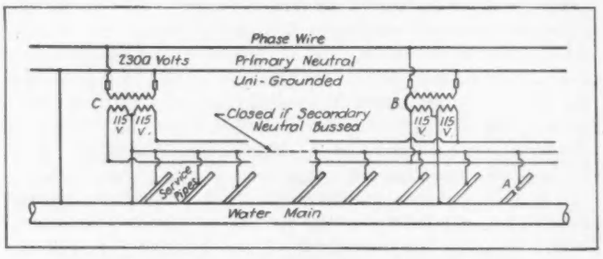


Fig. 2—Two-neutral, uni-grounded system in California

the opening in case of a transformer fault at either (B) or (C) whether or not the secondary neutral is bused as indicated by the dotted line.

With multigrounding of the primary neutral, conditions are still more safe, as can be seen in Fig. 3. A break at (A) cannot conceivably result in a high potential across the opening. Multigrounding of the primary neutral has been practiced in California for many years, and the practice is being extended rapidly in order to obtain the benefit of its many operating advantages.

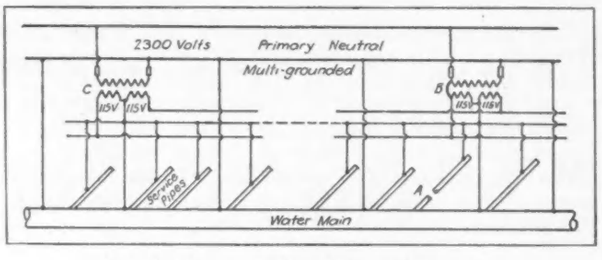


Fig. 3—Two-neutral, multigrounded system

The common-neutral system proposed is illustrated in Fig. 4. So far as safety is concerned, it appears to be of the same degree as the two-neutral multigrounded system shown in Fig. 3. With so many connections between the neutral and ground in either system, no dangerous potential will exist between the open ends of a disconnected water service in case of breakdown from a primary phase wire to the neutral.

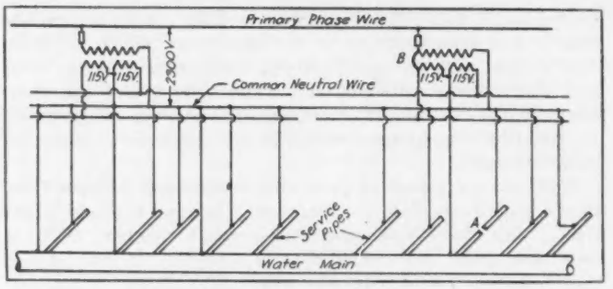


Fig. 4—Four-wire common-neutral system

Under the use of the common neutral, the nearest approach to the dangerous condition shown in Fig. 1 would be in case of injury to the grounding connection of a transformer serving a single load on the end of a single-phase run which is not operated common neutral, but which has the primary neutral ungrounded, except at the point where it leaves the three-phase lead. This condition is the same as might exist in the

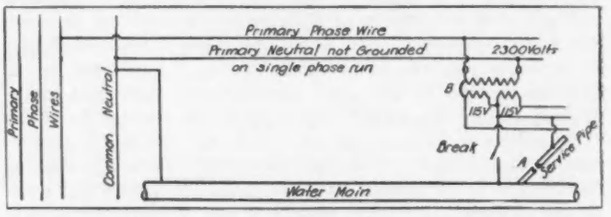


Fig. 5—Single-phase run with neutral not grounded except at branching point

uni-grounded system. The method of running the primary neutral ungrounded beyond the branching point is suggested in the Practices as a measure of coordination. However, conditions requiring a single service from a transformer on a long single-phase feeder are very rare, and the dangerous condition should be guarded against under any system.

Break in Neutral Wire

In considering a break in the neutral wire, the same illustrations (Figs. 1 to 5), will be referred to, assuming in each case that the transformer breakdown at (B) has not occurred.

In the installation shown in Fig. 1, a break in the neutral wire would render the transformer inoperative. Before a very dangerous potential could exist on the piping, the transformer must break down and the service pipe must be disconnected. Needless to say, the three occurrences are not likely to be coincident.

In the two-neutral uni-grounded system of Fig. 2, a break in the primary neutral would also render the transformers beyond the break inoperative. The secondary neutral may or may not be continuous or "bused." The water system and the earth with which it is everywhere in contact, are in parallel with the secondary neutral in the various sections, and the multiplicity of connections through services and at the transformer render this type of installation unquestionably safe, even if a second event occurs such as a breakdown at a transformer.

In the two-neutral, multigrounded system of Fig. 3, still greater safety exists. In case of a break in the primary neutral, the transformer will still operate, with the secondary neutral, if continuous, paralleling the water system and earth. If this neutral is not continuous, the earth, in combination with the water system, will carry the return current in the section where it is omitted, for most of the current will return to the primary neutral at the nearest ground connections.

In the common-neutral system of Fig. 4 only one neutral

wire exists. In case of a break in this neutral, the transformers beyond the break will be dependent upon the earth and water system in the short section between ground connections on the two sides of the break. Under normal conditions, services, and therefore ground connections, will be rather frequent, so no very high voltage can be built up. If in addition the transformer should break down, a larger demand would be made upon the path shunting the break, but the low resistance of this path with all its connections and ground-contact surfaces, promises a very low voltage rise.

In the single-phase run with primary neutral ungrounded, illustrated in Fig. 5, a break in the neutral would render the transformer inoperative, as in the case of Fig. 1. Because of the existence of the transformer ground, it is far safer than that condition discussed by the Bureau of Standards, and would require that this ground connection be broken in addition to the occurrences listed in reference to Fig. 1.

General

In the preceding discussion only single elements of the various systems have been treated. In the normal case several transformers, each with its ground connection, will serve a given area. There will be several services with their respective ground connections, rather close together, from each transformer. The neutral wires on parallel runs will be connected in a grid wherever practicable. The water piping, instead of one main as shown, will usually consist of an extended grid, or there may be cases where ground conductivity alone is depended upon through ground-rod connections. In case of transformer breakdown, the cutouts will remove the danger as soon as the fuses can operate. With the low resistance of the many ground connections, one being close to the transformer, the resulting voltage rise will not be dangerous, even momentarily.

One can conceive of a succession of failures which would bring about a dangerous condition on any of the systems. Except in a major catastrophe, not over one or two possible failures are likely to occur at one time, and their consideration should suffice to check for safety, and to indicate safeguards which should be applied. The lack of danger with multiple ground connections is emphasized in Technologic Paper No. 108 above mentioned.

It appears to the power group that a grounding plan which is adequate for the two-neutral multigrounded system would also be adequate for the common-neutral system, and that no additional hazard is introduced. This is borne out by the varied practices as to grounding in the localities outside of California where the common-neutral system is used, as reported to the subcommittee. These vary, from entire dependence on secondary service grounds except at transformers and the substation, to grounding to the water main at intervals of 800 ft. with four driven grounds to the block, between. No accidents have been reported anywhere as due to the use of a common neutral wire.

Fundamentally, it is the low resistance and not the interval between ground connections which is important. The requirement of a resistance of not over 3.5 ohms between the common neutral conductor and ground, as called for in the commission's special construction rules to govern the installations during the trial period, seems a reasonable requirement, and it can be met readily in most parts of California. For safety this minimum should be maintained in case of any single break in the neutral conductor.

The resistances of individual grounds are in many cases above this figure, but the resistance of the neutral grid to ground is usually well below it as measured by the three-point method or by special ground-resistance-measuring instruments. High resistance readings are reported from Palm Springs, but they are inconsistent and have little bearing on safety. When 170 ohms is indicated as the resistance of the neutral grid-to-ground, it merely means that the instrument is including the resistance of the auxiliary ground connection used, which in the same measurement is reported as of the same value.

What is needed is a low resistance from any part of the common neutral grid to the neutral at the substation transformer bank. If the neutral wire is No. 4 minimum, with larger sizes on the main feeders near the substation, the grid resistance cannot be more than the resistance of the mile or two of No. 4, No. 2, No. 0, and perhaps larger, wires back to the substation. The lowest values indicated in such tests are the true values of resistance of the grid to ground at the measuring points. Multiple-ground connections yield other paths shunting the neutral wire, thus further reducing the resistance back to the substation neutral.

As the secondary grounds in Palm Springs are reported of such high values, it is apparent that if continuity is maintained, the common neutral, in which the secondary neutral is combined with the primary neutral back to the substation, has decided advantages, from the standpoint of safety, in that area.

In regions where ground resistances are high, safety can be secured by an alternate requirement that the resistance from the neutral grid to the ground at the substation shall not exceed a certain value, which may be somewhat less than 3.5 ohms. However, because of the difficulty of measurement, secure joints and demonstrable calculations should be acceptable in lieu thereof. It is also essential that the resistance of the ground connection at the substation be correspondingly low.

Inductive Coordination—Experience With Areas Cut Over

The factors involved in inductive coordination between power distribution circuits and local telephone circuits may be divided into three general classes, namely, the characistics of the power distribution circuits or "influence" factors, the characteristics of the telephone circuits or "susceptiveness" factors, and the relations of proximity of the two types of circuits or "coupling" factors. The most important elements in each class are set forth in similar order in Table I, in which are also included condensed data regarding the effect on noise conditions. A large amount of detail has of course been omitted and only a brief summary is given of conditions in each area and the general effect of the change.

Each column of the table lists for a particular power substation area its size and general nature and methods of service. Items showing the nature of the telephone equipment serving the same area are next listed. The coupling data include brief items regarding exposure of the telephone circuits to railway and other high-voltage circuits, as well as to the 4-kv. common neutral, the latter being further subdivided into exposures in joint use and at street separation. Curves or tabulations give the relative amount of telephone cable exposed to the common neutral circuits.

The lower space shows the results of noise tests made before and after the cutover of the power system to common neutral, no changes being made on the telephone system, and in the Alhambra and Substation No. 2 columns, of similar tests made twenty months and fourteen months later, respectively. These noise data are chosen from results of tests made shortly before and shortly after the cutover, at representative locations and under specified arrangements of the telephone apparatus to show the immediate effect of the change. Additional data, covering variations of noise with apparatus arrangements and variations with time, over the daily cycle as well as over long periods, would of course be necessary to present a complete view of the situation. It will be noted that the noise characteristics vary considerably among the areas; that the later tests show reduction in Substation No. 2 area and increase in Alhambra; and that the

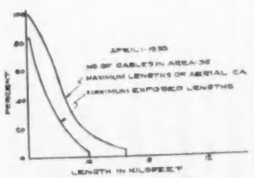
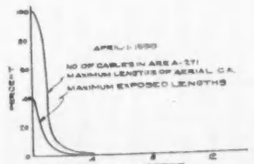
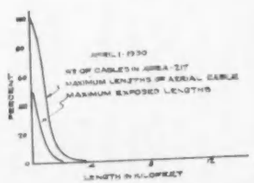
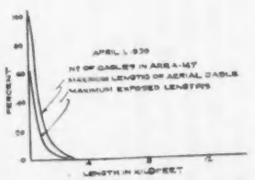
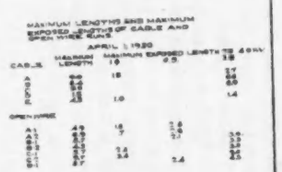
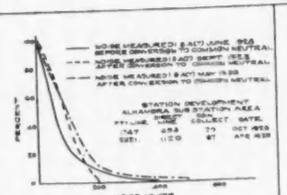
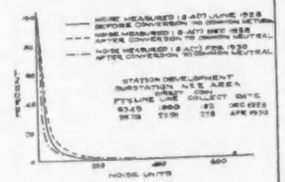
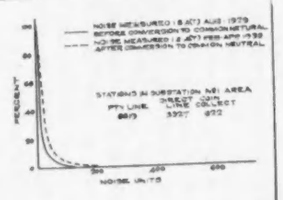
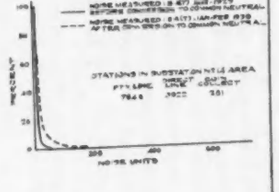
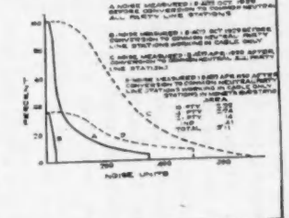
SUBSTATION AREA	ALHAMBRA	SUBSTATION Nº2	SUBSTATION Nº1	SUBSTATION Nº 1.4	MONETA
POWER SYSTEM DATA					
POWER COMPANY	SOUTHERN CALIFORNIA EDISON CO.	LOS ANGELES GAS & ELEC. CORP	LOS ANGELES GAS & ELEC. CORP	LOS ANGELES GAS & ELEC. CORP	SOUTHERN CALIF. EDISON CO.
APPROXIMATE AREA IN SQ MI	2.5	4.5	4.0	2.3	4.6
CAPACITY SUBSTATION SUPPLY BANK AND CONNECTIONS	1 BANK 6000 KVA 66/4 KV D/Y	1 BANK 3000 KVA; 1 BANK 3000 KVA 16.3/4 KV D/Y	2 BANKS 3000 KVA EACH 16.3/4 KV D/Y	2 BANKS 3000 KVA EACH 16.3/4 KV D/Y	1 BANK 1500 KVA 16.5/4 KV D/Y
LOAD - % LIGHTING - % POWER	62 - 38	47 - 53	60 - 40	92 - 38	75 - 25
NO. OF FEEDERS	8	6	7	10	4
4KV CCT LENGTH (K#) 3Φ - 0Y - 1Φ	137 - 66 - 7	172 - 0 - 105	175 - 0 - 50	147 - 0 - 14	87 - 40 - 2
C.N. CCT LENGTH (K#) 3Φ - 0Y - 1Φ	137 - 66 - 7	172 - 0 - 105	175 - 0 - 50	147 - 0 - 14	87 - 40 - 2
CHARACTERISTICS OF AREA	SMALL CITY - BUSINESS AND RESIDENTIAL SOME INDUSTRIAL	DENSE RESIDENTIAL - CONSIDERABLE INDUSTRIAL AND RETAIL BUSINESS	DENSE RESIDENTIAL - SOME RETAIL BUSINESS	WELL DEVELOPED RESIDENTIAL - APARTMENT HOUSE AND RETAIL BUSINESS	SMALL TOWN - SCATTERED RESIDENTIAL AGRICULTURAL OR OUTSKIRTS
TELEPHONE SYSTEM DATA					
TELEPHONE COMPANY	SOUTHERN CALIF. TEL. CO.	SOUTHERN CALIF. TEL. CO.	SOUTHERN CALIF. TEL. CO.	SOUTHERN CALIF. TEL. CO.	SOUTHERN CALIF. TEL. CO.
TYPE OF SYSTEM	MANUAL	MANUAL & DIAL (5X5)	MANUAL & DIAL (5X5)	MANUAL & DIAL (5X5)	MANUAL
TYPE OF CORD OR CONNECTOR CIRCUIT	W.E. REPEATING COIL	MANUAL - W.E. REPEATING COIL DIAL - BRIDGED RETARD. COIL - SERIES CONDENSER	MANUAL - W.E. REPEATING COIL DIAL - BRIDGED RETARD. COIL - SERIES CONDENSER	MANUAL - W.E. REPEATING COIL DIAL - BRIDGED RETARD. COIL - SERIES CONDENSER	KELLOGG 2-WIRE MULTIPLE-BRIDGED RELAYS - SERIES CONDENSER
NUMBER OF STATIONS	1158 - 2021 - 87	2591 - 9576 - 278	3527 - 8819 - 872	3022 - 7648 - 281	41 - 470 - 3
DIRECT LINE - PARTY LINE - COIN COLLECT					
PARTY LINE SERVICE AND METHOD OF SIGNALING	2 PTY SEL. & 4 PTY SEMI-SEL. WITH GROUNDED RINGING	2 PTY SEL. & 4 PTY SEMI-SEL. WITH GROUNDED RINGING	2 PTY SEL. & 4 PTY SEMI-SEL. WITH GROUNDED RINGING	2-PTY SEL. & 4 PTY SEMI-SEL. WITH GROUNDED RINGING	10 AND 4 PTY. SEMI. SELECTIVE, AND 2-PTY. SEL. WITH GROUNDED RINGING
TYPE OF STATION SET	W.E. 534-A OR EQUIVALENT	W.E. 534-A OR EQUIVALENT	W.E. 534-A OR EQUIVALENT	W.E. 534-A OR EQUIVALENT	KELLOGG - 73% SINGLE COND. 150 COIL; 27% " " 300 " ; KELLOGG 78-A - 100%
TYPE OF RINGERS ON ... PER CENT OF STATIONS	W.E. 8-A - 100%	W.E. 8-A 100%	W.E. 8-A 100%	W.E. 8-A - 100%	
COUPLING DATA					
AERIAL CABLE COUPLING (K#) D.C. RAILWAY - OTHER DIST. H. TENSION 4KV (3Φ - 0Y - 1Φ)	7 - 0 - 12 42 - 26 - 2	21 - 30 - 21 48 - 0 - 33	5 - 14 - 10 35 - 0 - 26	13 - 29 - 14 41 - 0 - 9	7 - 15 - 61 15 - A - 2 CABLE 29 - 11 - 18 OPEN WIRE
% 4KV AERIAL CABLE COUPLING JOINT USE - ST SEPARATION	65 - 35	79 - 71	31 - 69	50 - 50	65 - 37 CABLE 73 - 27 OPEN WIRE
PER CENT OF CABLES HAVING MAXIMUM LENGTHS OR MAXIMUM EXPOSED LENGTHS EQUAL TO OR GREATER THAN CORRESPONDING ABSCISSA					
NOISE DATA					
PER CENT OF PARTY LINE STATIONS HAVING NOISE EQUAL TO OR GREATER THAN CORRESPONDING ABSCISSA					

TABLE I—SUMMARY OF CHARACTERISTICS OF COMMON-NEUTRAL AREAS

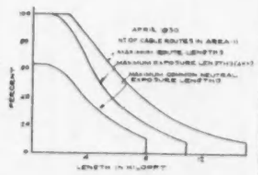
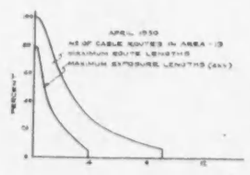
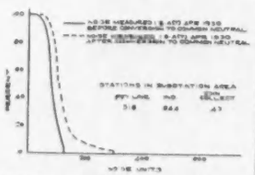
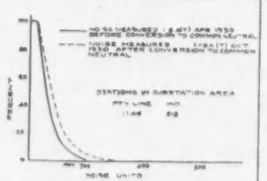
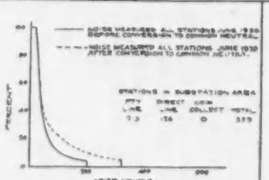
VENTURA	MIRA VISTA (RICHMOND)	CHICO	LINDEN	LAGUNA BEACH	PALM SPRINGS
POWER SYSTEM DATA					
SOUTHERN CALIF EDISON CO. .25 2-BANKS 3000 KVA EACH @ 3¾ KV D/Y 90-10 PART OF ONE 4.5-4.2 - 3.5 4.5-4.2 - 3.5 RESIDENTIAL- PRACTICALLY UNDEVELOPED	PACIFIC GAS & ELECTRIC CO. .65 1-BANK 1500 KVA 11/4 KV D/Y 80-20 ONE WITH 4- BRANCHES 68-38-105 68-0-0 SMALL TOWN- SCATTERED RESIDENTIAL	PACIFIC GAS & ELECTRIC CO. 7.2 1-BANK 2200 KVA 60/4 KV Y/Y 3 153-39-7 SMALL TOWN- MOSTLY RESIDENTIAL WITH SOME RETAIL BUSINESS	SOUTHERN CALIF EDISON CO. 3.0 1-BANK 3000 KVA 11.5/4 KV D/Y 80-20 4 65-27.5-14 65-27.5-14 RESIDENTIAL- NOT FULLY DEVELOPED	SOUTHERN CALIF EDISON CO. 2.0 1-BANK 1500 KVA 11.5/4 KV D/Y 97-3 4 52-65-3.4 52-65-3.4 SMALL TOWN - RESIDENTIAL NOT FULLY DEVELOPED	SOUTHERN SIERRAS POWER CO. 2.0 1-BANK 2250 KVA 17.33/4 KV Y/D/Y 96-4 4 34.4-7.5 7.5 4 SMALL TOWN SPREAD OUT - SCATTERED RESIDENTIAL AND SOME BUSINESS
TELEPHONE SYSTEM DATA					
SOUTHERN CALIF TEL. CO. DIAL (3 x 5) BRIDGED RETARD COIL SERIES COND. NONE AS OF 8-1-30 2-PTY SEL & 4-PTY SEMI-SEL WITH GROUNDED RINGING W.E. 534-A OR EQUIVALENT W.E. 8A - 100%	THE PACIFIC TEL & TEL CO. MANUAL W.E. REPEATING COIL 544-318-43 2-PTY SEL AND 4-PTY SEMI-SEL WITH GROUNDED RINGING W.E. 534-A OR EQUIVALENT W.E. 8A - 100%	THE PACIFIC TEL & TEL CO. MANUAL W.E. REPEATING COIL 86-1148-0 2-PTY SEL AND 4-PTY SEMI-SEL WITH GROUNDED RINGING W.E. 534-A OR EQUIVALENT W.E. 8A-100%	ASSOCIATED TEL CO. LTD. DIAL (3 x 5) BRIDGED RETARD COIL SERIES CONDENSER 9-906-14 4-PTY SEL HARMONIC GRADED RINGING 4-PTY " " METALLIC " A.E. CO. DOUBLE COND. TYPE 21 AE CO HARMONIC 16, 23, 33, 50, 66 CYCLE - 100%	ASSOCIATED TEL CO. LTD. MANUAL KELLOGG REPEATING COIL 126-213-0 8-PTY SEL HARMONIC GRADED RINGING 2 & 4-PTY " " METALLIC " KELLOGG SINGLE COND. 30 OR EQUIVALENT KELLOGG HARMONIC 16, 33, 50, 66 CYCLE - 100%	SOUTHWESTERN HOME TEL. CO. DIAL (3 x 5) BRIDGED RETARD COIL SERIES CONDENSER. 4-FREQUENCY HARMONIC METALLIC RINGING KELLOGG 18-2 CONDENSER IND. COIL KELLOGG HARMONIC 16, 33, 50, 66 CYCLE - 100%
COUPLING DATA					
0-0-0 32-10-0 100-0 TEST POINT EXPOSURES TEST POINTS / EXPOSURES LENGTH (KF) / POWER CCT / SEPARATION 1 1.5 — CN — 2 1.0 — CN — 3 1.0 — CN — 4 3.3 — CN —	29-21-15 TOTAL 4KV COUPLING 27-0-3 " C.N. " 73-27 	10-0-6 25-6-0 CABLE 27-7-2 OPEN WIRE 90-10 	0-0-0 1.2-2.4-0 CABLE 37-69-0 OPEN WIRE PRACTICALLY ALL CABLE AND OPEN WIRE EXPOSURES ARE AT JOINT USE SEPARATION MAXIMUM LENGTH OF 4 KV EXPOSURE TO CABLE 1.2 KF OPEN WIRE 4.6 KF	0-0-75 29-3-3 CABLE 147-21.2-29 OPEN WIRE 98-2 CABLE / MAXIMUM LENGTH / MAXIMUM 4 KV EXPOSURE A 2.0 KF 1.9 KF. B 1.5 1.3 C 1.1 .5 D 6.4 1.2 OPEN WIRE A-1 5.9 5.0 B-1 1.3 1.3 D-1 5.9 6.8	0-0-8 5-1-10 36-8.4 TEST POINT EXPOSURES T.P. / EXPOSURE LENGTH (KF) / POWER CCT / SEPARATION 1 2 3 4 5 6
NOISE DATA					
NOISE VALUES AFTER COMMON NEUTRAL CONSTRUCTION TEST POINT / 1-6A 1 / 40 2 / 30 3 / 65 4 / 130 NOTE - NO NOISE MEASUREMENTS WERE MADE BEFORE CONSTRUCTION ON ACCOUNT OF NO PLANT IN PLACE	 NOTE: INCIDENTAL SHIELDING IS PRESENT ON ALL EXPOSED CIRCUITS	 NOTE: NOISE MEASUREMENTS ON OPEN WIRE CIRCUITS WERE NOT INCLUDED IN ABOVE CURVES		 NOTE - PERCENT IS BASED ON TOTAL NUMBER OF STATIONS IN AREA	NOISE VALUES AFTER CONVERSION T.P. / 0 SECOND / 6 SECOND / BRIDGED / No 1 2 3 4 5 6 NOTE: NO 50 MEASUREMENTS WERE MADE BEFORE CONVERSION 0 USUALLY CONVERSION READILY NOTICED 6 & TWO CONVERSION ERRORS NOTICED

TABLE I (continued)—SUMMARY OF CHARACTERISTICS OF COMMON-NEUTRAL AREAS

noise is in rough proportion to the length of exposure.

In general there has been an increase in noise, in most cases rather moderate, following the cutover to common neutral. It should be appreciated that similar noise increases would have been experienced if the system had been cut over from delta to the multigrounded, two-neutral system now in common use for similar effectiveness of grounding.

Except for the areas of Alhambra and Substation No. 2, the results after cutover herein presented are limited to initial observations closely following the conversion of the respective areas. In the Alhambra area the later tests showed an increase in noise. Upon checking conditions in that area, it was found that a new feeder had been installed and in the readjustment certain provisions of the Practices had not been followed. When the installation had been restored to conformity with the Practices, the noise was reduced to approximately the value obtained immediately after the cutover. In the Substation No. 2 area the later tests showed a reduction in noise. This is a further indication of the variations which may be expected between areas and from time to time. It is, of course, recognized that an extended period of actual experience with operation of the Practices is required to determine fully their suitability.

In the Ventura area an existing 4-kv., 4-wire system was extended, the new portions only being made common neutral. As there was no telephone plant serving those portions at the time of this construction, the only noise readings are those taken after the common neutral extension was made. Advantage was taken of the circumstances in this case for advance planning on both systems in accordance with the Practices. In all the other areas the change was a cutover from delta-supply at about 2,300 volts to Y-supply at about 4,000 volts with the common primary and secondary neutral.

A preliminary investigation of the large increase in noise in Moneta indicated that the application of the Practices could be expected to reduce the noise materially. Work in this area has not yet been completed. Suitable measures will be taken by the interests concerned in this area, and in others where reduction in noise is necessary and practicable.

Savings to Power Company

The initial saving to the power company in each area in construction and rearrangement costs is rather definite. The work of changing over was done under definite work orders upon which the actual costs for the change to the common-neutral system were entered. From these it can be readily estimated what the cost would have been in each case if the change had been to the two-neutral multigrounded system, and the consequent saving. Costs of coordination other than those inherent in the initial cutover are discussed in the next section of this report.

Table II presents the costs of the cutover to common neutral in the various areas, from the records of the power companies, the estimated costs which would have been incurred if the two-neutral multigrounded system had been installed, and the consequent savings. In the areas cut over, many items of reconstruction or system betterments are included in the cost figures, though not chargeable to the common-neutral conversion. In the table these are presented as costs of "rebuilds" and deducted from the gross costs to obtain the net costs of cutover.

The table indicates a total saving, in the eleven areas tried out, of $33,075 out of an estimated cost of $308,453 if two-neutral multigrounded installations had been made. This is 10.7 per cent of the gross estimated cost of the two-neutral systems, or 17.8 per cent of the net cost after deductions have been made for the "rebuilds." The savings vary from 4.3 per cent to 15.7 per cent of the gross costs, or from 10.7 per cent to 55.8 per cent of the net costs, in the various areas.

By inspection of the table it is readily seen that the proportion of total cost used on rebuilds varied considerably among the areas and affected the percentages of the savings to a large degree. Further differences in conditions also influenced the results.

The areas in the south were cut over completely to common neutral, including the single-phase and open-Y runs. In the Mira Vista area only the three-phase portions were made common-neutral, the single-phase and open-Y runs being connected two-neutral, the primary neutral being ungrounded beyond the branching point. This lessened materially the possible savings in that area. In Chico long primary runs and thin load density affected the results similarly. In general the greatest savings were realized in areas which are well built up and have high load densities; the least savings, in sparse areas with low load densities.

Another factor tending to reduce the savings in many of the areas was the necessity of changing the neutral wire, formerly the secondary neutral, to a larger size to conform to the commission's special construction rules.

After the common-neutral system has been established in an area for a number of years, the savings will be in more constant proportion to the existing distribution capital. They come under the following headings:

Copper (roughly from one wire out of seven on three-phase portions with parallel secondary wires, to one wire out of five on single-phase runs).
Pins and insulators (same proportions as wire).
Neutral deadends (one-half).
Fuse cutouts (one-half).
Pin position (this has a value, as in some cases a reconstruction is avoided or deferred).

To offset these savings will be the cost of establishing extra grounds on the common-neutral, in case more are required than on the multigrounded system. In some of the areas cut over during the trial period the grounding requirements lessened the power savings materially.

The detailed cost figures from which the tabulations were made are available in the subcommittee's files.

Costs of Coordination

Plans for coordination of the two classes of circuits may involve work on either or on both systems. In future exceptions, the relative circuit layout can be planned ahead to avoid exposure as much as practicable. On the power systems, checking and correcting transformer excitation and load balance will help, and the use of Y/delta transformer banks,

TABLE II—SUMMARY OF POWER SYSTEM COSTS AND SAVINGS

Substation Area	Alhambra	Sub. No. 2	Sub. No. 1	Sub. No. 14	Moneta	Ventura	Mira Vista (Richmond)	Chico	Linden	Laguna Beach	Palm Springs	Total
Power Company	So. Cal. Ed. Co.	L. A. Gas & Elec. Corp.	L. A. Gas & Elec. Corp.	L. A. Gas & Elec. Corp.	So. Cal. Ed. Co.	So. Cal. Ed. Co.	Pac. Gas & Elec. Co.	Pac. Gas & Elec. Co.	So. Cal. Ed. Co.	So. Cal. Ed. Co.	So. Sierras Power Co.	.....
Estimated Gross Cost—Two-Neutral	$16,626	$49,809	$48,288	$48,007	$19,223	$ 4,748	$17,318	$28,734	$40,610	$21,958	$13,132	$308,453
Actual Gross Cost—Common-Neutral	14,059	43,569	40,716	43,042	16,671	4,418	15,917	26,307	37,506	21,003	12,170	275,378
Savings by Common Neutral	$ 2,567	$ 6,240	$ 7,572	$ 4,965	$ 2,552	$ 330	$ 1,401	$ 2,427	$ 3,104	$ 955	$ 962	$ 33,075
% Savings over Gross Two-Neutral Cost	15.4%	12.5%	15.7%	6.2%	13.3%	7.0%	8.1%	8.4%	7.6%	4.3%	7.3%	10.7%
Cost of Rebuilds Either System	$ 4,746	$20,162	$ 5,062	$ 9,963	$13,941	$ 2,748	$ 4,871	$ 6,144	$35,043	$14,081	$ 6,306	$123,067
Estimated Net Cost—Two-Neutral	$11,880	$29,647	$43,226	$38,044	$ 5,282	$ 2,000	$12,447	$22,590	$ 5,567	$ 7,877	$ 6,826	$185,386
Actual Net Cost—Common-Neutral	9,313	23,407	35,654	33,079	2,730	1,670	11,046	20,163	2,463	6,922	5,864	152,311
Savings by Common-Neutral	$ 2,567	$ 6,240	$ 7,572	$ 4,965	$ 2,552	330	$ 1,401	$ 2,427	$ 3,104	$ 955	$ 962	$ 33,075
% Savings over Net Two-Neutral Cost	21.6%	21.0%	17.5%	13.0%	48.3%	16.5%	11.2%	10.7%	55.8%	12.1%	14.1%	17.8%

with neutral connected to the common neutral is a possible measure to suppress excessive triple harmonics. On the telephone system, shielding by thoroughly grounding the cable sheath is the simplest expedient, resulting in a 40 to 70 per cent reduction in noise on the cable circuits. In specific cases, special subscriber sets or circuit arrangements may be employed to reduce the susceptiveness.

In view of the variety of measures available for coordination in the power and communication systems, it is impracticable to present definite figures for the costs of coordination. A further difficulty arises from the fact that the costs of continuing administration cannot be accurately estimated from the present limited experience. From estimates based on the noise data of Table I and experience to date in those areas where effective cable-grounding is practicable, it is believed that the costs of coordination will be substantially less than the economies indicated. However, in areas where cable-sheath grounding is impracticable, alternative measures required on the part of the communication company may reduce the over-all economy.

General Conclusions

The power group believe the common-neutral system, properly constructed, to be fully as safe as the two-neutral multigrounded system, and with multigrounds, more safe than the delta or uni-grounded Y system. The important consideration from the safety standpoint is the maintenance of a low resistance from all points on the neutral conductor to the neutral at the substation, which is also connected to ground. When this is accomplished, safety is assured. Multiplicity of ground connections affords additional assurance in this respect, as reiterated in the Bureau of Standards publication mentioned.

The trial period and the studies which preceded it, as well as the experience since obtained on areas cut over, show conclusively that it is practicable to coordinate the common-neutral system with the cable telephone plant. The Practices, which were drawn up as a result of the preliminary study, appear to promise effective inductive coordination between the common-neutral system (or the two-neutral multigrounded system, which was found to have similar inductive effects) and the exchange telephone plant. Continued experience with the Practices, as well as study of the economics involved, may be expected to indicate more fully the practicable limitations of the common-neutral system. Full consideration should be given, by the companies concerned, to the various factors involved, to determine whether or not it is economical to install such a system in any specific situation. In coordination, emphasis should be placed upon advance planning, as with it the costs of mitigation may be reduced to small values and in some cases eliminated. With the information now at hand even better results than have been obtained in the trial may be anticipated from preliminary attention given to circuit layouts on both power and telephone systems.

Experience to date indicates that the savings noted here, even clouded as they are by costs of reconstruction and system betterments independent of the actual change, will be materially higher than the costs of coordination. The savings to the public should increase as the systems are extended and reconstruction of existing facilities is not involved. In addition to the appreciable savings, the power group believe that the additional safety, more reliable relay operation, etc., are important gains.

Recommendations

1. That General Order No. 64A be amended to permit the use of a common primary and secondary grounded neutral wire on four-wire overhead distribution systems of 5,000 volts or less.

2. That the inductive coordination between the power and telephone companies in reference to the common-neutral system be conducted under the general provisions of General Order No. 52 (particularly Sections I and VI).

3. That the Practices as now amended be recognized as the guide for the detailed inductive coordination involved, to be modified only by mutual agreement of the interests concerned as the need may be indicated by further experience.

Concurring in this report are engineer representatives of companies which have been involved in the application of the common-neutral system during the trial period and of companies not yet involved but which have watched the results of the trial with interest.

Inductive Coordination[1]

The work of this subcommittee consisted of reports and detailed discussions on cases of advance planning and inductive coordination, only the most important of which are presented herewith.

Advance Planning

11-Kv. Parallel—McArthur to Bieber[2]

THE Pacific Gas and Electric Co. constructed an 11-kv. line from McArthur to Bieber, Shasta County, paralleling the telephone circuits of the Fall River Valley Telephone Co., a farmer organization, and the Redding-Alturas toll circuit of the Public Utilities California Corp. The power line was 18 miles long, three-wire, three-phase. The single-phase loads were served by means of 11-kv. transformers between phases and three-phase loads with 6.9 kv. transformers connected ungrounded star to delta. The farmers' line consisted of a one iron-wire circuit largely at road separation, although overbuilt for one-half mile, with many poor joints insulated with small knobs on short poles and trees, with the wire off the knobs and down in the brush in many places. The toll circuit is metallic, except for a section of about 12 miles between Bieber and a point 1½ miles east of Pittville. A single-wire section is at separations varying from ¼ to 1 mile for about 7 miles, with two crossings, and then at road separations.

Before the line was put in service, arrangements were made with both telephone companies to energize the 11-kv. line and to observe the effects on the telephone circuits. Measurements were made of voltage-to-ground and of approximate noise. The voltage-to-ground on both lines was too low to be recorded with a 100,000-ohm thermocouple voltmeter. The noise on the farmer lines was estimated to be in the order of 100 noise units; that on the toll circuit was somewhat less.

Joint Power and Telephone Construction—Moreno Valley and City of Corona*

The following two instances are typical of the joint planning of the Southern Sierras Power Co. with the Southwestern Home Telephone Co., covering portions of Moreno Valley, and with the Southern California Telephone Co., involving the city of Corona within the Circle Blvd.

The Moreno Valley territory, comprising about twenty sq.mi., was partially covered with pole facilities of The Southern Sierras Power Co. before the installation of a new automatic plant by the Southwestern Telephone Co. These poles were used by the telephone company wherever possible

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[1] Report of subcommittee on inductive coordination, foreign systems coordination committee, Engineering Section. F. B. Doolittle, chairman. V. D. Armstrong, D. I. Cone, A. W. Copley, T. J. Fleming, A. S. Glasgow, W. F. Grimes, C. Grunsky, O. A. Gustafson, H. N. Kalb, H. S. Lane, R. E. Northmore, G. E. Nott, E. Y. Porter, S. Rapp, M. A. Sawyer.

[2] Written by H. S. Lane for the subcommittee on inductive coordination, foreign systems coordination committee, Engineering Section.

* Written by A. C. Putman for the subcommittee on inductive coordination, foreign systems coordination committee, Engineering Section.

in routing circuits. A map showing the routes of the proposed new pole lines was prepared by the telephone company and submitted to our engineers. This map indicated that telephone service was to be provided for ranches which were not then served with electricity. A visit to these ranches by our commercial representatives determined whether pole space should be provided on the new telephone poles for power company use. This information was furnished the telephone company, and a revised plan for pole setting was prepared. Several changes in our existing construction were made to provide legal clearances for telephone company attachments. Combinations were made on power company poles which carried either 440-, 2,300- or 4,000-volt circuits, but no attachments were made on the 33- or 87-kv. lines passing through the valley. Only one instance of inductive coordination entered this joint planning layout. The Southern California Telephone Co. was to string a toll circuit from the toll line on the Perris Highway for a distance of 3¾ miles along the new lead of the Southwestern Home Telephone Co. on Allessandro Blvd., to connect with the new Exchange Bldg. This would have involved the possible joint use of 1½ miles of our 4,000- and 440-volt distribution line poles then in place. Such combination use was not thought desirable by the Southern California Telephone Co.'s toll engineers, so a duplicate lead was set on the opposite side of the highway.

The city of Corona within Circle Blvd. is well laid out to accommodate joint construction. Alleys intersect at right angles in nearly every block, and the whole circular area, nearly one mile in diameter, is crossed from north to south and from east to west by streets extending entirely across the circle.

Dilapidated duplicate telephone leads occupied both sides of alleys, making legal construction for both companies very difficult to maintain. Our distribution system in general was also in bad shape, and many conflicts existed which could be eliminated only by complete reconstruction by both parties.

A preliminary field inspection was made by the telephone and power company engineers, and a mutual understanding of each other's requirements was obtained. It was decided that all new pole lines for combination use should be erected in the north and south alleys. The layout was complicated by the necessity of making use of some construction of both companies, which was still suitable for joint use and was also further complicated by a 50-ft. toll lead carrying 16 arms of open wire and running at right angles to the proposed new combination leads.

Tentative pole locations were staked by our surveyors, and a map showing such locations, together with pole heights and other data, was submitted to the telephone company engineers. After field checking by the telephone company, the layout was approved with some few alterations. Poles were then set by The Southern Sierras Power Co. Painted and treated cedar poles were used generally, and 1-in. anchor rods were set for combination use where required. The complete reconstruction involved approximately 350 poles, varying in height from 35 to 60 ft., the telephone company purchasing a one-third interest at a 23-ft. grade in all poles 45 ft. or higher.

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*Low Frequency Induction Tests on the Southern Sierras Power Company Hoover Dam Transmission Line**

After the completion of the Hoover Dam transmission line by The Southern Sierras Power Company, a series of cooperative tests was made to determine the ground resistivity, induced voltages on the power company's telephone line and the Southern California Telephone Company's San Bernardino-Las Vegas toll line under fault conditions on the transmission circuit, and to determine the shielding effect if a ground wire were used on the power circuit. The results of these tests showed the ground resistivity, and therefore the low-frequency induction coupling, to be somewhat lower than was expected. A single ground wire gave a 39 per cent reduction in coupling.

The data obtained will be of considerable value in determining the necessity for remedial measures when the power line voltage is increased and power received from the Hoover Dam hydro-electric project.

THE inductive coupling at fundamental frequency between the Hoover Dam transmission line of the Southern Sierras Power Company and the Southern California Telephone Company's San Bernardino-Las Vegas toll line was determined by tests. Similar measurements were also made on the power company's telephone dispatching line which is associated with the transmission line between San Bernardino and Hoover Dam. In addition to obtaining the overall inductive coupling of the two telephone lines, the tests included the measurements of the coupling in several sections of exposures of fairly uniform separation, in order that a determination of ground resistivity could be accurately made. results of tests indicated a somewhat lower value of earth resistivity than was anticipated and consequently the overall coupling was less than was originally expected.

As outlined in a previous report, considerable attention was given, prior to the construction of the Hoover Dam 132-kv. transmission line, to the selection of a route which would result in a minimum of inductive exposure to the Southern California Telephone Company's San Bernardino-Las Vegas toll line, extending along the same general route. Through the cooperative efforts of representatives of the two companies, a practicable route was selected for the transmission line, such that induction from normal operation of the power line was not expected to be serious. Consideration was also given, in selecting the route, to the avoidance of low frequency induction coupling as far as practicable. However, due to the nature of the territory traversed and to the fact that the shortest and most practicable route for the power line was essentially that already occupied by the toll line, it was not found practicable in many sections to obtain separations sufficiently great to avoid a considerable amount of low frequency induction exposure.

The total length of exposures at various separations involving the telephone company's toll line and also the power company's telephone line is as follows:

Separation	Length of Exposure in Miles S. C. Tel. Co.	S. S. Power Co.
Less than 2,000 ft.	5.9	19.3
Between 2,000 and 4,000 ft.	28.3	98.1
Between 4,000 and 5,000 ft.	26.7	21.9
Between 5,000 and 10,000 ft.	61.7	45.2
Total less than 10,000 ft.	122.6	184.5
Total over 10,000 ft.	99.7	37.8

Total length of power line—222.3 miles.

The details of the exposure are shown in Fig. 1. In this exposure chart, the telephone company's toll line and the power company's telephone dispatching circuit are plotted with respect to the power line. The dotted portions indicate that the separation is greater than 10,000 ft.

The voltage which will be induced along paralleling telephone circuits from power system fault current flowing through ground depends largely on three factors, namely, (a) the amount of fault current, (b) the separation between the power and telephone circuits, and (c) the ground conduc-

* Written by M. A. Sawyer for the subcommittee on inductive coordination, foreign systems coordination committee, Engineering Section.

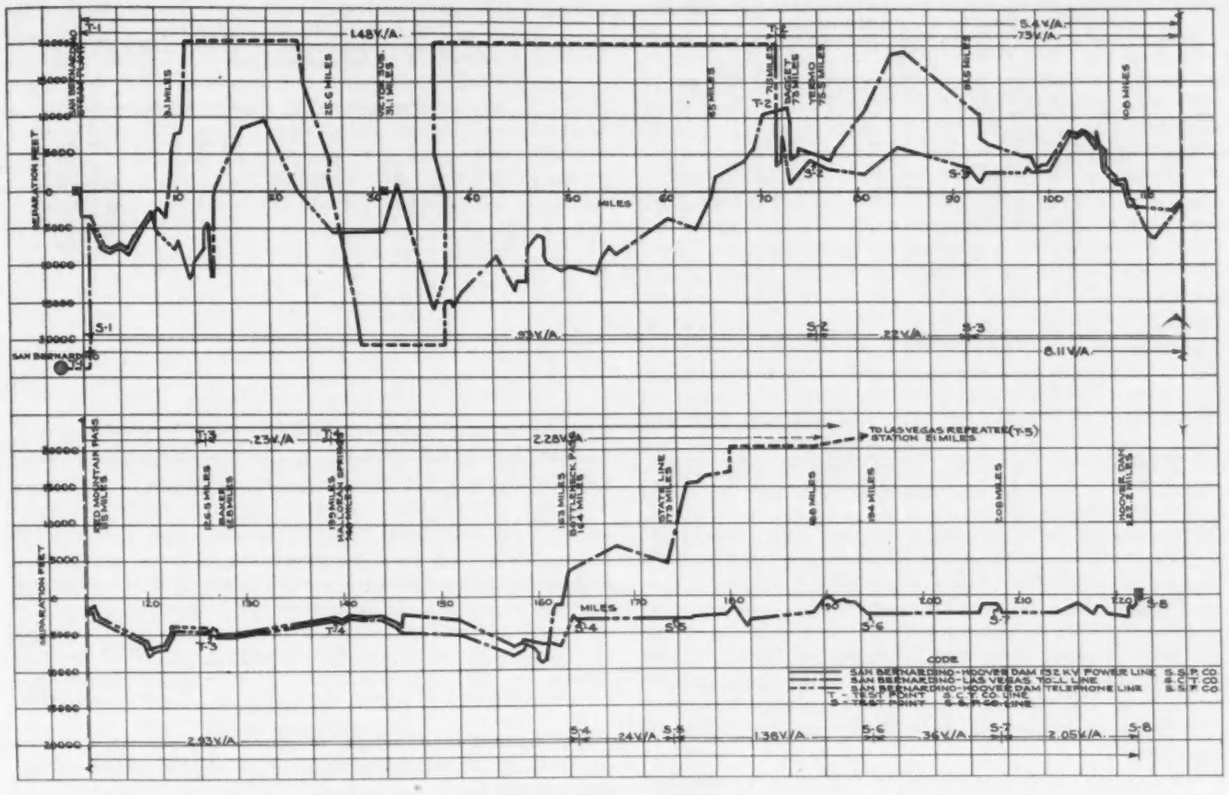

Fig. 1—Exposure diagram

tivity or resistivity. While the first two items can be readily obtained by inspection or calculation for a given situation, tests are generally required for an accurate determination of the ground resistivity. Ground resistivity has been found to vary considerably in different locations and with different types of earth formations, and is influenced by the presence of pipe lines, rails and other metallic structures. As is readily apparent from the following values of induced voltage per ampere of fault current at a few separations, the value of earth resistivity that obtains is an important factor in the resultant coupling. The variation of the coupling with separation is also indicated.

Earth Resistivity Meter-Ohms.	Coupling Volts per Amp. at Various Separations ¼ Mile	½ Mile	1 Mile
10	0.032 V/A	0.0085 V/A	0.0022 V/A
100	0.126 V/A	0.064 V/A	0.0216 V/A
1,000	0.25 V/A	0.181 V/A	0.015 V/A

It may be well here to explain the difference between the term "resistivity" which is now being applied in low-frequency induction work, and the term "conductivity" which has been used in the past. Carson's formula for the mutual impedance of ground return circuits is based on the conductivity of the earth in abmhos per centimeter cube. Through the work of the joint D. & R. subcommittee of the N.E.L.A. and Bell system, it has been found desirable to use a practical unit of earth resistivity in place of the absolute unit of conductivity. The new unit, which is termed the "meter-ohm," represents the resistance in practical units between opposite sides of a meter cubed of earth, while the unit of conductivity was based on the conductivity in absolute units between opposite sides of a centimeter cube of earth. The following table shows the relation between resistivity and conductivity in these units:

Meter-Ohms Resistivity	Abmhos/cm.³ Conductivity
1	10^{-11}
10	10^{-12}
75	1.33×10^{-13}
100	10^{-13}
150	6.67×10^{-14}
1,000	10^{-14}

Since no data were available as to the ground resistivity that might be expected in the mountainous and desert sections involved in the major portion of the exposure, it was not possible to determine to any degree of accuracy by calculations the low frequency induction coupling that would result. A series of tests were, therefore, jointly made before the transmission line was placed in service. In addition to measuring the overall coupling between the power line and the telephone company's toll line and the power company's telephone circuit, measurements were made to field test points at various locations along the two telephone lines, as shown in Fig. 1. These test points were selected to include, in some cases, sections of fairly uniform separation exposure for which the value of ground resistivity could be quite accurately determined.

Fundamentally, the tests consisted of sending current over a circuit made up of the power line phase wires as one side of the circuit, and ground as the other side, and measuring the voltage induced to ground on the paralleling telephone circuits. The power line was energized at a low voltage to ground at the San Bernardino steam plant and the phase wires were shorted and grounded at Hoover Dam. The single-phase 60-cycle power supply was obtained from a frequency changer operating through a transformer. The power supply arrangement and associated metering equipment are shown in Fig. 2.

The induced voltages on the telephone lines were also measured at the steam plant as indicated. Some measurements were also made at the field test points and at the far end. The ground to which the measurements were made was,

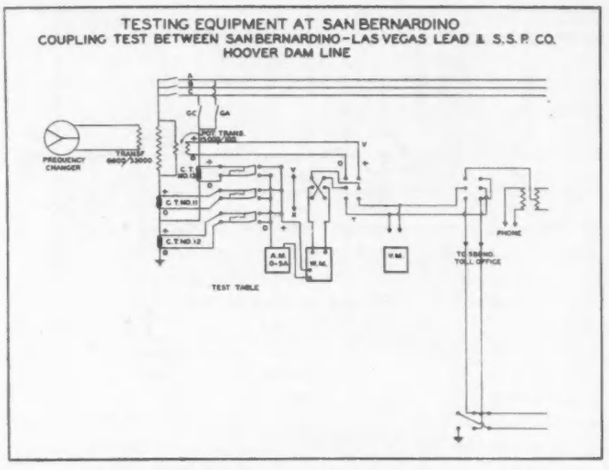
TESTING EQUIPMENT AT SAN BERNARDINO
COUPLING TEST BETWEEN SAN BERNARDINO-LAS VEGAS LEAD & S.S.P. CO. HOOVER DAM LINE
FREQUENCY CHANGER
TEST TABLE
PHONE
TO SBDNO. TOLL OFFICE

Fig. 2—Testing equipment at San Bernardino

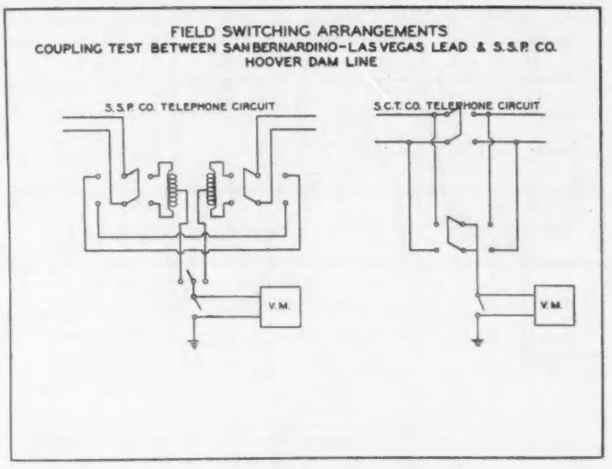
FIELD SWITCHING ARRANGEMENTS
COUPLING TEST BETWEEN SAN BERNARDINO-LAS VEGAS LEAD & S.S.P. CO. HOOVER DAM LINE
S.S.P. CO. TELEPHONE CIRCUIT
S.C.T. CO. TELEPHONE CIRCUIT
V.M.
V.M.

Fig. 3—Field switching arrangements

however, located at the telephone company's San Bernardino toll office in order to avoid the effect of ground potentials which would result from a flow of current in the power station ground. In addition to measuring the power current and induced voltages, measurements were also made of the phase angle between the current and induced voltage by the voltmeter-ammeter-wattmeter method. This measurement was made so that phase change could be taken into account in obtaining the induced voltages for some of the individual test sections.

Carefully calibrated thermocouples, built out by means of external resistance to 1,000 ohms per volt, were used in measuring the induced voltage. At the field test points, the arrangements for grounding the telephone lines and measuring the voltage was as shown in Fig. 3. To enable the power company's telephone circuit to be used as a dispatch circuit, repeating coils were cut in at the test points and the ground was obtained as shown.

The results of the over-all tests, as well as the tests of individual test sections, have been noted on Fig. 1. The coupling values in volts per ampere (V/A) shown along the top of the chart are for the telephone company's line, while those along the bottom are for the power company's telephone line. These data, together with the computed ground resistivity and approximate average separations are summarized in the following table:

INDUCED VOLTAGE AND EARTH RESISTIVITY BY TEST SECTIONS

Test Section	Length of Exposure in Miles*	Approx. Avg. Separation in Thousand Feet	Measured Induced V/A	Approx. Avg. Earth Resistivity Meter-Ohms
Southern California Telephone Company Line				
T-1 to T-2	53.1	8.0	1.48	139.0
T-2 to T-3	55.0	7.7	0.73	43.4
T-3 to T-4	12.5	4.6	0.23	58.8
T-4 to T-5	41.8	7.1	2.28	312.0
T-1 to T-5	162.4	7.4	5.40	164.0
Southern Sierras Power Company Line				
S-1 to S-2	40.8	6.9	0.93	58.8
S-2 to S-3	16.0	3.9	0.22	20.0
S-3 to S-4	72.5	4.5	2.96	91.0
S-4 to S-5	9.0	3.1	0.24	38.4
S-5 to S-6	21.0	2.6	1.38	80.0
S-6 to S-7	14.0	2.5	0.36	25.0
S-7 to S-8	14.2	2.6	2.05	476.0
S-1 to S-8	187.4	3.7	8.10†	80.7

*Separation less than 20,000 feet.
†Obtained by direct addition of measured values for intermediate test sections.

In order to obtain a rough idea of the amount of reduction in induced voltages that might be expected if a ground wire were present on the power line, tests were made, using one and also two of the power phase wires as ground wires. In this test, the power wires were grounded at both the steam plant and Hoover substation ends and, with the remaining wires or wire energized, the induced voltage was measured. The reduction in overall coupling of the telephone company's line was as follows:

	Coupling
No shielding	5.4 V/A
1-phase wire used as ground wire	3.3 V/A—39 per cent reduction
2-phase wires used as ground wires	2.5 V/A—54 per cent reduction

The amount of shielding, of course, depends on the conductivity of the ground wire, location of that wire with respect to the phase wires, and the resistance of grounds obtained at each tower. The size of wire used in these tests was 4/0 ACSR.

In comparing the measured induced voltage per ampere for the section between Victorville and Hoover Dam, with that estimated during the preliminary work in connection with the selection of the power line route, it was found that a close agreement is obtained when a value of a 100 meter-ohms is assumed for ground resistivity. The estimated coupling at 100 meter-ohms was 3.6 volts per ampere, while the measured coupling for this section was 3.9 volts per ampere. The coupling of 3.9 corresponds to an average earth resistivity of approximately 101 meter-ohms.

In general, the earth resistivity, as indicated by the test data, was considerably lower than was anticipated for this type of territory. It was naturally expected, judging from surface conditions, that this arid and desert country would have a rather high ground resistivity in the order of 1,000 meter-ohms or even higher. The comparatively low values obtained would tend to indicate the presence of ore bodies or other conducting formations or possibly subsurface water In any event, it was gratifying to find that, due to the low earth resistivity, the low frequency induction coupling was somewhat lower than was expected.

With the transmission line supplied from San Bernardino steam plant and the present connected kva. of generator and synchronous condenser capacity, it has been estimated that a zero resistance fault-to-ground at Hoover substation will result in a fault current of approximately 22 amp. The total voltage with this amount of current flowing through the entire exposure which would be induced on the telephone company's and power company's lines would be 119 and 178 volts respectively. The amount of fault current which will flow under actual operating conditions will, of course, depend on the location of the fault with respect to the terminals of the line and the resistance of the contact to ground.

The data which were obtained in these cooperative tests will be of considerable value in determining the necessity for the application of remedial measures when the voltage

of the power line is increased and power is received from the Hoover Dam hydro-electric project, or in the event other system changes are made which tend to increase the amount of current which may be delivered in case of faults to ground on this line. The ground resistivity information will also be very helpful in working out future inductive coordination problems which may be encountered in connection with the construction of other transmission lines to Hoover Dam or in other sections where comparable ground conditions can be expected.

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*Remote Alarms by Carrier Current Over Distribution Circuits**

Where is it desirable to obtain remote indications and communication lines are not available or are too costly, the desired result may be accomplished by carrier current over distribution supply circuits at a cost of approximately $1,500 for a single alarm system.

IN order to give an indication of switch operation at unattended automatic distribution substations, the Southern California Edison Company has developed a simple equipment which transmits the signal over 11-kv. or 16-kv. lines by carrier current.

Alarm System

The alarm transmitter and receiver are coupled to the power system by means of coupling capacitors and protective equipment. The coupling capacitors are 0.004 microfarad 16-kv. and are used on either 11-kv. or 16-kv. circuits. Drainage coils are located in the cabinet inclosing the carrier apparatus, one coil being connected from each capacitor to ground, to limit the voltage from the carrier equipment to ground to a low value by providing a low impedance path at commercial frequency. A horn gap to ground is also connected to the low-voltage side of each capacitor, which will spark over in case a drainage coil should open and would carry the heavy current to ground if a capacitor broke down.

The carrier-current transmitter uses one 7½-watt tube connected in a self-rectifying Colpitts oscillator circuit. The frequency of the oscillator may be set between 50 and 100 kilocycles by taps on the oscillator inductance. The oscillator output is transferred to the line-tuning coil through a coupling coil which is also variable by taps. The circuit formed by the line and the capacitor is resonated by selecting the taps on the line-tuning coil which give maximum carrier-current output. Each transmitter is equipped with a thermocouple milliameter which indicates the carrier-current output. All of the voltages required for the operation of the vacuum tube are alternating current, supplied from a transformer, no batteries being used. Thus the transmitter operates only on those alternate half cycles on which the tube plate potential is positive with respect to the filament. The transmitter requires a maximum of fifty watts at ninety per cent power factor from the 115-volt a.c. supply when operating.

The carrier current receiver is also very simple, consisting of an untuned primary coil connected to the capacitors, and inductively coupled to a secondary coil which is tuned by a variable condenser. The one tube used is connected as a biased power detector. The coil of a sensitive telephone-type relay is connected in the detector plate circuit and the contacts of this relay close the alarm circuit. The relay is provided with both normal and back contacts so that the alarms may be operated either when a carrier current signal is being received or at such times as there is no signal. Thus the alarm systems can be used as either open-circuit or closed-circuit. With the open-circuit alarm, a signal is transmitted only at such times as an alarm is desired. This also posseses the advantage of a lesser maintenance, due to the longer tube life of the transmitter tube. If the closed-circuit connection is used, the signal is transmitted continuously, except during the time an alarm is desired. This has the advantage of being self-indicating in case of trouble in the alarm system. The receiver tube is continuously energized with alternating current, ten watts being required, and consequently it functions only on alternate half cycles. In order that the maximum signal may be received, it is necessary that the supply for the receiver be in phase with that for the transmitter.

Since a single communication channel at a given carrier frequency only uses alternate half cycles of the commercial supply frequency, two channels can be provided on a single carrier frequency without interference. This is accomplished by using two receiver tubes so connected to the plate voltage supply transformer that their plates will be positive on alternate half cycles. Then one of the receivers may be actuated by supplying energy to the transmitter in the normal direction and the other receiver will respond to the same transmitter when the 115-volt a.c. leads supplying the transmitter are reversed.

In each application a satisfactory frequency must be determined by field test to get satisfactory operation under different conditions of the power network.

Operating Experience

Of course the alarm bells may be sounded by high frequency induced by switching or other surges of the particular frequency used, including lightning in the distribution system to which the alarm is connected. These indications are of very brief duration and are, therefore, easily distinguished from actual alarms.

The six-carrier-current alarm systems in use have been in service a total of 26 months. In this time they have responded to 217 surges caused by switching and lightning. They have functioned correctly on 39 test operations and have given 66 correct alarms on switch kickouts. There have been 29 false alarms, ten of which were due to a weak tube in one of the systems which is operated as a closed-circuit alarm. Six more of the false operations are chargeable to this one system, which is connected to a distribution network and gives a very weak signal under normal conditions. Any switching change from the normal brings in an alarm in this case. The remaining 13 false alarms probably can be accounted for by the operator mistaking the momentary bell caused by a surge on the line for an actual alarm. This mistake is easily made with automatic reclosing switches, if the operator does not hear the bell to judge the time it rings and only notices the target on his annunciator.

Conclusion

Where it is desirable to obtain one or more remote indications, when communication lines are not available and the cost of building or leasing them is excessive, the desired result may be accomplished by carrier current over the supply circuits. The cost of a single alarm system installed on a 16-kv. circuit is about $1,500. If two alarms operate into the same station, so that a double receiver can be used, the cost per alarm system is reduced to about $1,200, installed.

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* Written by F. B. Doolittle for the subcommittee on power company communication systems. H. S. Lane, chairman. V. D. Armstrong, R. B. Ashbrook, K. B. Ayres, A. W. Copley, L. J. Corbett, W. F. Grimes, C. Grunsky, O. A. Gustafson, C. B. Judson, R. E. Lake, H. J. Schomberg, W. C. Smith.

*Selective Signalling Equipment For Power Company Telephone Circuits**

A signal circuit comprising a combination of standard telephone relays and selective switches has been devised to meet the problem of busy locations where a multiplicity of bells resulted in confusion.

IN general, the telephone circuits of the power company are relatively long magnetic circuits with a number of stations connected. The signaling is accomplished by audible code signals. Two problems have aggravated the signaling situation. At locations where a number of busy lines congregate, the multiplicity of bells and continual code ringing result in an unsatisfactory condition. The operation of stations by a single operator, particularly a 24-hour man who is off duty at night, introduces an additional problem.

The solution of these problems required the development of selective signaling equipment applicable to such circuits which must meet the following requirements:

It must be applicable on any or all lines at any station without requiring material equipment changes at other stations.

It must operate at the nominal ringing frequency of 20 cycles derived from hand generators or ringing machines.

The line relays must be sufficiently sensitive to operate on long heavily loaded lines.

The equipment must be exclusively selective for the code assigned.

The code system should not be unduly cumbersome and should offer the least possible interference with existing signals.

The resulting signal must be sustained until cleared by the operation of answering, or by a subsequent ring on the line.

The equipment must consist of standard telephone apparatus of proven reliability.

A signal circuit comprising a combination of standard telephone relays and selective switches was devised to meet these requirements. This equipment responds to a code involving one long ring with a number of short rings preceding or succeeding, according to the assignment for the particular station.

This equipment is mounted in equipment racks arranged in units accomodating the maximum of twenty lines per unit. The relay equipment is associated with trunk-line jacks on standard PBX boards or with cordless boards constructed in 10-line unit cabinets which may be grouped to accomodate any number of lines.

* Written by H. S. Lane for the subcommittee on power company communication systems.

*Radio Coordination**

The report of this committee covers the subjects of the need for investigation of possible interference to television in the short wave field; unit cost of handling radio complaints; methods of preventing complaints by routine correcting of causes; the use of choke coils on old style transformers; interference from pin type insulators.

THE following is an outline of the main activities of the subcommittee on radio coordination for the fiscal year 1931-32.

Need for Investigation of Short Wave Interference

Much has been done with radio coordination in the past few years. When this work first started, broadcasting was just becoming popular and due to the rapidity with which the public accepted radio broadcasts, it was a very difficult task for the utilities to keep pace with the new developments. Television is now approaching; the Federal Radio Commission has already recognized this by assigning frequency bands for such broadcasts, and they have also issued experimental licenses to a considerable number of stations. Just what this new development is going to mean to the power company is yet to be determined. However we must be foresighted in starting investigations as to the probable interference that may be expected when broadcast pictures are to be received by radio.

Some time ago the government assigned two channels for picture broadcasts; one 2,000 to 2,300 kilocycles, and the other 2,750 to 2,950 kilocycles.

Very recently licenses have been granted to four different broadcasting stations in the East, allowing them to operate on a wave length of approximately 7 or 8 meters. These experimental stations are following out the tests and experiments carried on during 1930 in Berlin, where experiments were made with broadcasting on wave lengths varying from 3.2 to 11.6 meters. These short waves were tried for both sound and pictures. The interesting part of these tests, for this committee, is shown in the following quotation which is taken from an article written by Eric Schwandt of Berlin:

It was also found that the waves between six and eight meters were subject to electrical disturbances to a degree 10 to 100 times less than long waves; in fact the only interference observed being that from ignition systems of motor cars.

There are probably two angles to this problem; first, is the amount of interference now present greater in these bands than in the present broadcast band? Second, how much field strength must noise or interference have, before it will interfere with the reception of pictures? A study of these problems with the results presented to the Federal Radio Commission, might be the means of saving the industry much expense and bettering public relations.

It was brought out that for good quality radio reception at the present time there must be a differential in the order of twenty decibels between broadcast signal strength in micro-volts per meter and noise level in the same units. It was felt that the telephone company's experience in photo transmission by wire might be of value if we could learn what were the comparative noise levels which they allow in their photo transmission as compared with that tolerated on their voice channels.

Unit Cost of Handling Radio Complaints

A report was given on the work of the Radio Trades Association of Southern California for the first eleven months of 1931. It was found that this association had handled 3,011 complaints during that time at a unit cost of investigation of $4.26. The City of Los Angeles adopted a new ordinance regarding radio interference in December, 1931. This new ordinance places some responsibility on the owner of the radio set, inasmuch as it specifies a minimum signal strength necessary, and also refers to the length and type of the outside antenna.

Routine Inspections to Prevent Radio Complaints

The Pacific Radio Trades Association, which handles the radio complaint investigations around the San Francisco Bay area, recently has been doing a certain amount of routine inspection work with good results. The radio inspector, with a company representative, rides over the lines with his receiving set, listening for interfering noises. When a noise is heard, it is investigated and traced. If it is a small matter, such as a loose fuse or lug, it is corrected immed-

* Report of subcommittee on radio coordination, foreign systems coordination committee, Engineering Section. H. N. Kalb, chairman. V. D. Armstrong, R. B. Ashbrook, C. C. Campbell, A. W. Copley, G. H. Curtiss, F. B. Doolittle, A. S. Glasgow, W. F. Grimes, C. Grunsky, O. A. Gustafson, C. B. Judson, R. E. Lake, S. Rapp, M. A. Sawyer, H. G. Schomberg, W. C. Smith, G. R. Walters.

iately. If it is more than a one-man job, or requires material to correct, it is reported to the company and corrected later.

The Southern Sierras Power Company makes like corrections through the medium of patrolmen and servicemen. who, after receiving advice as to the most common and frequent causes, are instructed to keep alert and to correct them whenever found. These men then make a written report of the condition as found and its correction to the radio engineer. This method of eliminating radio complaints has proved very effective.

The San Diego Consolidated Gas & Electric Co. is getting the best results by a systematic test of deadends and other line insulators and by removing or replacing every unit which appears to be defective. A surprising number of deadends are found to be in such bad condition that they will actually carry enough current to light a lamp through a potential transformer.

Choke Coils

The San Joaquin Light and Power Corporation has developed a choke coil for use on the primary side and a condenser for the secondary side of the older distribution transformers, to suppress interference where it is not economical to correct the trouble by other means. This method uses one choke coil in each primary lead from the line to the transformer and condenser across the secondary leads of the transformer. Very good results have been obtained.

Pin-Type Insulators

Various types of pin insulators are in trial service to correct interference. Glass and metal-coated porcelain insulators are being tried in salt fog and sandstorm areas for the effect of fog and the abrasion of sand. The results of Prof. F. S. McMillan's work on this subject at the Oregon Agricultural College were discussed in detail.

A case was described where correction of trouble by using a copper braid around the top of the insulators had apparently been satisfactory at first. However, there remained a discharge around the copper braid which caused the formation of nitric acid, and a consequent deposit between the braid and the porcelain to such an extent that approximately a year later it was found that the noise level was higher than its original value, and that the copper braid was practically eaten away.

Big Creek 2-2A producing 156,000 kva. for the Southern California Edison Co. Ltd. at 2,290-ft. and 1,760-ft. heads

HYDRAULIC POWER COMMITTEE REPORTS[1]

*Mechanical Reliability of Hydro-electric Units**

Statistics on the operation of generating units within the territory of the Pacific Coast Electrical Association have now been presented for eight successive years. The addition of each year's record adds to the value of the report.

THE subcommittee on mechanical reliability of hydro-electric units presents herewith the eighth annual report on the operation of generating units within the territory of the Pacific Coast Electrical Assn. The same word of caution in studying and analyzing the report that has prefaced previous reports must again be emphasized, and the reader should bear in mind that care must be taken in the forming of conclusions, because a full knowledge of the factors which have caused large or unusual outages is necessary before direct comparisons of equipment can be made. Outages may be due to faulty design, installation or operation, but it is not practical to differentiate the contributing causes in a tabular report without an extensive supplementary explanatory history. In comparing results, therefore, care must be taken that injustice is not done to a manufacturer whose equipment may have been improperly installed or operated or that a poor machine, well maintained and operated, is not put above a good machine which is improperly maintained and operated. The report as presented is a truly representative cross-section of general conditions, and the results herein set down are average and what may well be expected in practice over a period of time. The addition of each year's record of operation adds to the value of the report, because the irregularities of infrequent and periodical overhauls and renewals become smoothed out in the average of a long period of time, the final statistics representing more truly the probable performance of the equipment in service.

The report for 1931 covers a total of 62 units installed in 30 plants and having a grand total of 1,508,380 hp. and 1,124,619 kva. There are 32 vertical turbine units with a total hp. rating of 757,480, driving vertical generators of a total capacity of 600,700 kva. The horizontal-shaft units were divided among four turbines with a total rating of 64,700 hp. and 26 impulse wheels with a total rating of 686,200 hp. driving 30 horizontal generators with a total rating of 523,919 kva. The vertical turbines range in size from 10,500 hp. to 44,000 hp. and average 23,671 hp. Speeds vary from 171.4 r.p.m. to 600 r.p.m. and static heads from 157 ft. to 820 ft.

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[1] C. B. Carlson, Southern California Edison Company Ltd., chairman. J. W. Jourdan, San Joaquin Light & Power Corporation, vice-chairman.
California Oregon Power Company: T. G. Bradley.
General Electric Company: H. E. Fuqua, H. C. Stanley.
Pacific Gas and Electric Company: T. J. Corwin, D. P. Dinapoli, H. V. Lutge, E. F. Maryatt, C. P. Vetter.
Pelton Water Wheel Company: R. L. Mahon, R. S. Quick.
San Joaquin Light & Power Corporation: H. K. Fox, F. R. Harp, E. A. Quinn.
Southern California Edison Company Ltd.: S. F. Coghlan, J. F. Davenport, G. C. Heckman, D. H. Redinger, E. M. Scott.
The Southern Sierras Power Company: C. L. Davis, E. J. Waugh, G. M. Wills, W. J. Young.
Westinghouse Electric & Manufacturing Company: R. J. Cobban, H. S. Warren.

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* Report of subcommittee on mechanical reliability of hydro-electric units. D. P. Dinapoli, chairman. T. G. Bradley, Geo. Heckman, J. W. Jourdan, B. H. Merritt, E. J. Waugh.

TABLE IV ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

HORIZONTAL TURBINE INSTALLATIONS

Plant Index Number	21			22			23		
Item — Cause	6 Yr.Av.	1931	7 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.
13. GENERAL HYDRAULIC CAUSES:									
(a) Ice or Trash							1.25		1.04
(b) Floods									
(c) Penstock or Canal	58.66		50.28	803.00	2647.00 b)	1033.50	8.10		6.75
(d) Headgates or Intake							2.40		2.00
(e) Other General Hydraulic		3.16	0.45	2.43		2.13	6.36		5.30
(f) TOTAL GENERAL HYDRAULIC:	58.66	3.16	50.73	805.43	2647.00	1035.63	18.11		15.09
14. WATER WHEELS AND AUXILIARIES:									
(a) Runner				19.43	34.00	21.25	17.24		14.37
(b) Shut-off Valve							6.09		5.08
(c) Turbine Gates or Needle Nozzle	.42	4.00	0.93						
(d) Guide Bearings or Main Bearings	47.19	6.00	41.31	4.14		3.62	1.32	1.30	1.32
(e) Thrust Bearing				3.28		2.87			
(f) Governor and Governor System	6.85		5.87	.43		.38	4.55	6.40	4.86
(g) Pressure Regulator or Deflectors	.17		.15	154.71		135.37	3.02		2.52
(h) Draft Tube		4.00	.57				.25		.21
(i) Lubrication System	1.31		1.12						
(j) Vibration	.50		.43						
(k) Seal Rings	1.16	6.42	1.91	2.28		2.00	45.98		38.32
(l) Inspection	1.20		1.03	3.43		3.00	.28	x 9.75	1.86
(m) General Overhauling and Replacement	.50		.43	311.00		272.13			
(n) Other Causes	1.48		1.27				17.55		14.62
(o) TOTAL WATER WHEEL:	60.77	20.42	55.02	498.70	34.00	440.62	96.28	17.45	83.16
15. GENERATOR AND APPURTENANCES:									
(a) Vibration									
(b) Lubrication or Oil Leakage									
(c) Motor or Field	1.87		1.60	.43		.38	1.48	5.83	2.21
(d) Armature Iron or Windings	303.71		260.32				1.63		1.36
(e) Exciter and Rheostats	.15		.13	2.85		2.49	.20		.17
(f) Ventilation System	12.39		10.62	2.43		2.13			
(g) Cleaning				2.43		2.13			
(h) Inspection	.10	.27	.12	.28		.25			
(i) Other Causes	.52		.45	.28		.25	1.33	a)25.93	5.43
(j) TOTAL GENERATOR:	318.74	.27	273.24	8.71	0	7.63	4.64	31.76	9.17
16. TOTAL ALL CAUSES.- (13+14+15)	522.63	23.85	378.99	1312.86	2681.00	1483.88	119.09	49.21	107.42
17. NUMBER OF UNITS COVERED	2	2	2	1	1	1	1	1	1
18. AVERAGE OUTAGE HOURS PER UNIT	261.32	11.93	189.50	1312.86	2681.00	1483.88	119.09	49.21	107.42

x Seal Rings and Runners
a)Miscellaneous Repairs
b)Enlarging Canal

TABLE I — HYDRO-ELECTRIC PLANT DATA
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

INDEX NUMBER	KIND OF OPERATION	UNITS COVERED	RATED H.P.	YEAR	STATIC HEAD	NUMBER RUNNERS	R.P.M.	SETTING	GENERATOR KV-A.	GENERATOR P.F.	PRESSURE CONTROL	SHUT OFF VALVE TYPE	SHUT OFF VALVE SIZE	SHUT OFF VALVE CONTROL	GOVERNOR OIL SYSTEM	GOVERNOR DRIVE
VERTICAL TURBINE INSTALLATIONS																
1	Daily Peak	2	20,000	1925	157	1	171.4	Plate Steel Spiral	15,000	0.90	Surge Chamber	Butterfly	140	Motor & Hand	Individual	Belt
2	Run of River	2	23,400	1928	607	1	514.	Cast Steel Spiral	20,000	0.80	Surge Chamber & Relief Valve	Butterfly	72	Motor & Hand	Individual	Belt
3	Daily Peak	1	15,000	1921	216.8	1	225.	Cast Iron Spiral	12,500	0.80	Pressure Regulator	Butterfly	90	Motor	Individual	Belt
4	Base Load	1	15,000	1921	197.9	1	225.	Cast Iron Spiral	12,500	0.80	Flume Spillway	Gates at Dam		Motor	Individual	Belt
5	Run of River	2	40,000	1922	454.	1	257.	Cast Steel Spiral	35,000	0.90	Pressure Reg.& Surge Chamber	Butterfly	108	Motor	Central	D.C.
6	Daily Peak	3	33,000	1925	315.	1	225.	Cast Steel Spiral	27,000	0.90	Pressure Reg.& Surge Chamber	Butterfly	108	Motor	Individual	Gear
7	R. of R. & D.P.	3	15,000	1920	350.	1	360.	Cast Steel Spiral	14,200	0.80	Pressure Reg.& Surge Chamber	Butterfly	84	Motor	Individual	D.C.
8	Run of River	1	12,000	1921	272.	1	257.	Plate Steel Spiral	10,600	0.80	Pressure Reg.& Surge Chamber	Butterfly	90	Motor	Individual	D.C.
9	R. of R. & D.P.	3	35,000	1923	818.	1	428	Cast Steel Spiral	28,000	0.894	Pressure Reg.& Surge Chamber	Plunger	54	Hyd., Hand & Motor	Central	Belt
10A	Daily Peak	1	30,000	1921	715.	1	428.	Cast Steel Spiral	25,000	0.90	Pressure Reg.& Surge Chamber	Plunger	72	Hyd., Hand & Motor	Central	Belt
10B	Daily Peak	1	44,000	1929	715.	1	375.	Cast Steel Spiral	35,000	0.90	Pressure Reg.& Surge Chamber	Butterfly	84"x2"	Motor & Hand	Central	Gear
11	Run of River	2	25,000	1921	820.	1	500/600	Cast Steel Spiral	17,500	0.90	Pressure Reg.	Plunger	60	Hyd., Hand & Motor	Central	Belt
12A	Base Load	4	16,500	1909	460.	1	400.	Cast Steel Spiral	10,000	1.00	Pressure Reg.& Surge Pipe	Gate	60	Motor	Central	Belt
12B	Base Load	2	18,500	1914-16	460.	1	400.	Cast Steel Spiral	12,500	0.80	Pressure Reg.& Surge Pipe	Butterfly	72	Hydraulic	Central	Belt
13	Seasonal Peak	2	17,690	1927	225.	1	277.	Riveted Steel Spiral	13,500	0.90	Pressure Regulator	Butterfly	102	Motor	Individual	Gear
14	Daily Peak	2	20,900	1920	535.	1	428.	Cast Iron Spiral	17,500	0.80	Pressure Reg.& Surge Chamber	Johnson	72	Hydraulic	Central	Belt
15	Base Load	1	10,500	1928	197.	1	257	Cast Steel Spiral	8,000	0.80	Relief Valve	Butterfly	72	Motor	Individual	Gear
HORIZONTAL TURBINE INSTALLATIONS																
21	Daily Peak	2	18,600	1918-22	125	2	200	Plate Steel Spiral	12,500	0.80	None	Gates at Intake	52457	Motor & Hand	Individual	Belt
22	Daily Peak	1	20,000	1917	519	1	360	Cast Steel Spiral	15,000	0.80	Pressure Regulator	Butterfly	66	Motor	Individual	Belt
23	Run of River	1	7,500	1924	245.4	1	400	Cast Steel Spiral	6,250	1.00	Relief Valve	Gate		Hydraulic	Individual	Belt
IMPULSE WATERWHEEL INSTALLATIONS																
31	Base Load	1	30,000	1921-24	1108	2	171.4		22,223	0.90	Pressure Reg.& Surge Chamber	Gate	42	Hydraulic	Central	Motor
32	Base Load & D.P.	2	35,000	1927	2563	2	450		25,000	0.80	Surge Chamber & By Pass Needle	Gate	26	Hydraulic & Motor	Central	Belt
33	Base Load	1	9,500	1921	1865	1	514		7,500	0.80	Jet Deflector	Gate	24	Motor	Individual	Belt
34	Daily & Seasonal	2	14,000	1923	1750	1	300		12,500	0.80	Pressure Reg.& Surge Chamber	Gate	28	Hydraulic	Individual	Belt
35A	Daily Peak	2	18,000	1913	1375	2	360		12,500	0.96	Deflecting Nozzles	Gate	36	Water Motor	Central	Belt
35B	Daily Peak	1	18,000	1922	1375	2	360		15,000	0.80	Deflecting Nozzles	Gate	36	Water Motor	Central	Belt
35C	Daily Peak	1	18,000	1928	1375	1	257		15,000	0.80	By Pass Needle	Gate	36	Water Motor	Central	Gear
36A	Daily Peak	2	20,000	1913	2080	2	375		17,500	0.80	Relief Valve & By Pass Needle	Gate	24	Hydraulic Hand	Central	Belt
36B	Daily Peak	1	22,500	1923	2080	2	375		17,500	0.90	Relief Valve & By Pass Needle	Johnson	24	Hydraulic-Hand	Central	Belt
36C	Daily Peak	1	35,000	1925	2080	2	300		28,000	0.894	Relief Valve & By Pass Needle	Plunger	30	Hydraulic & Motor	Central	Belt
37A	Daily Peak	2	20,000	1913	1855	2	375		17,500	0.80	Relief Valve & By Pass Needle	Gate	24	Hydraulic - Hand	Central	Belt
37B	Daily Peak	2	22,500	1923-25	1855	2	375		17,500	0.90	Relief Valve & By Pass Needle	Plunger	24	Hydraulic - Motor-Hand	Central	Belt
37C	Daily Peak	1	56,000	1928	2418	2	250		45,000	0.89	Surge Chamber & Jet Deflector	Gate	34	Hydraulic, Motor-Hand	Central	Gear
37D	Daily Peak	1	56,000	1928	2418	2	250		45,000	0.89	Surge Chamber & Jet Deflector	Gate	34	Hydraulic, Motor-Hand	Central	Belt
38	Run of River	4	10,750	1907	880	2	250		5,000	0.80	Deflecting Nozzle	Gate	28	Hand & Motor	Individual	Chain
39	Daily Peak	1	14,000	1924	1673	1	360		12,500	1.00	Jet Deflector	Gate		Water Motor	Individual	Belt
40	Daily Peak	1	40,000	1927	2381	2	360		33,000	0.94	Pressure Reg.& Surge Chamber	Gate	32	Hydraulic	Central	Belt
41A	Daily Peak	1	16,000	1923	930	2	200		12,500	0.80	Surge Chamber & By Pass Needle	Needle Valve	57	Hydraulic	Central	Belt
41B	Daily Peak	1	32,200	1928	930	2	143		25,000	0.80	Surge Chamber & Jet Deflector	Needle Valve	57	Hydraulic	Central	Belt
42	Base Load & D.P.	4	25,000	1925	1315	2	257		20,000	0.875	Surge Chamber & By Pass Needle	Gate	36	Hydraulic	Individual	Belt

TABLE X OPERATING RECORD
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.S.A.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT INDEX NUMBER	KILOWATT RATING OF EACH GENERATOR	YEAR	KILOWATT HOURS GENERATED	AVERAGE SERVICE TIME	AVERAGE IDLE TIME	TOTAL	ANALYSIS OF IDLE TIME								AVERAGE SERVICE DEMAND AVAILABILITY FACTOR (4) TIMES (15)
							AVERAGE TOTAL OUTAGE TIME (9)+(10)	AVERAGE OUTAGE TIME WHEN IN DEMAND	AVERAGE OUTAGE TIME WHEN NOT IN DEMAND	AVERAGE RESERVE TIME (6)-(8)	AVERAGE DEMAND TIME (8)+(9)	MAXIMUM POSSIBLE SERVICE TIME (6)+(11)	AVERAGE CAPACITY FACTOR (6) TIMES (14)	AVERAGE OUTPUT FACTOR (4) TIMES (7)	
1	13,500	6 Yr.Av	58,892,045	74.36	25.64	100	4.50	1.33	.80	21.30	27.08	95.67	.508	.671	.923
		1931	24,481,300	60.24	43.76	100	1.99	0.	1.99	41.77	45.24	98.01	.407	.363	1.000
		7 Yr.Av	51,957,771	71.97	28.21	100	4.16	1.01	1.11	24.04	74.80	97.82	.479	.628	.942
2	16,000	3 Yr.Av	76,093,170	88.29	11.71	100	.228	.131	.091	11.40	82.42	99.78	.542	.459	.988
		1931	78,351,400	89.63	10.37	100	2.80	.138	2.69	11.17	93.95	97.30	.557	.585	.990
		4 Yr.Av	76,722,285	89.32	10.68	100	.042	.010	.034	10.64	89.40	99.98	.549	.573	.988
3	10,000	7 Yr.Av	28,772,161	96.05	3.95	100	3.72	.23	3.49	.23	96.28	98.27	.492	.361	.988
		1931	22,359,000	99.99	.01	100	.01	.01	0.	0.	100.	99.99	.374	.374	1.000
		8 Yr.Av	25,138,750	96.54	3.46	100	1.26	.20	1.06	.20	96.74	98.74	.207	.299	.988
4	10,000	7 Yr.Av	41,198,360	95.60	4.39	100	1.561	.111	1.450	.837	95.91	96.44	.492	.515	.999
		1931	No Report												
		8 Yr.Av													
5	31,500	5 Yr.Av	139,529,000	61.51	38.49	100	2.31	0.	2.31	36.17	63.51	97.68	.506	.738	1.000
		1931	129,672,000	58.89	41.11	100	2.20	0.	2.20	38.91	61.09	97.80	.470	.688	1.000
		6 Yr.Av	134,107,750	61.41	38.59	100	2.29	0.	2.29	36.30	61.61	97.71	.487	.708	1.000
6	24,300	5 Yr.Av	158,396,666	88.61	11.39	100	2.58	0.	2.58	18.47	78.61	97.08	.568	.724	1.000
		1931	164,464,665	73.12	26.88	100	2.95	0.	2.95	23.93	73.12	97.05	.486	.665	1.000
		6 Yr.Av	118,069,099	77.72	22.19	100	2.53	0.	2.53	19.19	77.70	97.07	.556	.714	1.000
7	11,360	7 Yr.Av	61,385,741	93.69	6.31	100	2.32	.14	2.18	4.19	93.62	97.68	.615	.653	.998
		1931	43,807,487	93.10	.92	100	.80	0.	.80	0.	99.19	99.19	.641	.645	1.000
		8 Yr.Av	98,117,884	94.20	5.80	100	2.13	.12	2.01	3.67	94.32	97.87	.551	.627	.998
8	8,480	7 Yr.Av	46,138,000	97.68	2.31	100	1.02	0.	.39	99.60	98.05	.594	.60	.98	
		1931	29,423,000	99.81	.19	100	0.	0.	0.	.17	99.83	100.00	.597	.598	1.000
		8 Yr.Av	42,305,250	97.83	2.17	100	1.68	1.68	0.	.12	98.61	98.12	.609	.595	.983
9	25,000	6 Yr.Av	138,288,678	63.01	36.97	100	9.31	.34	8.97	23.68	69.78	90.66	.632	.956	.989
		1931	108,364,000	45.81	54.17	100	9.46	0.	9.46	44.71	45.81	90.54	.465	1.078	1.000
		7 Yr.Av	136,816,867	64.08	35.92	100	9.35	.65	8.70	26.42	64.65	90.65	.617	.943	.981
10A	22,500	7 Yr.Av	108,371,275	65.80	34.20	100	4.96	2.66	2.32	30.43	68.38	95.24	.540	.636	.987
		1931	16,213,200	10.28	89.72	100	10.96	0.	10.96	78.72	10.38	89.04	.089	.860	1.000
		8 Yr.Av	96,501,574	58.86	41.14	100	5.54	2.23	3.31	35.60	61.09	94.46	.491	.831	.972
10B	31,500	2 Yr.Av	126,808,571	78.37	21.62	100	2.24	.002	2.242	19.38	78.377	97.75	.598	.760	1.000
		1931	115,624,800	91.91	8.09	100	2.47	0.	2.47	10.37	91.06	97.53	.620	.723	1.000
		3 Yr.Av	121,342,315	71.66	28.40	100	2.35	0.	2.35	26.05	71.60	97.65	.538	.746	1.000
11	15,750	7 Yr.Av	73,458,678	67.98	32.41	100	5.68	.47	5.48	26.45	61.84	94.05	.532	.4158	.9328
		1931	51,287,000	59.85	41.15	100	5.89	0.	5.89	35.26	59.85	94.11	.496	.4158	1.000
		8 Yr.Av	68,917,315	66.96	33.00	100	5.64	.41	5.23	27.62	64.81	94.04	.514	.467	.9382
12A	10,000	5 Yr.Av	73,732,100	96.31	5.68	100	1.27	.21	1.06	2.615	94.32	98.73	.841	.889	.998
		1931	47,238,750	89.01	10.98	100	1.49	0.	1.49	9.50	89.01	98.51	.540	.624	1.000
		6 Yr.Av	60,322,875	90.08	9.91	100	1.47	.18	1.29	8.64	90.22	98.53	.731	.821	.998
12B	10,000	5 Yr.Av	68,197,900	94.84	5.14	100	1.17	.224	.95	3.97	94.67	98.85	.777	.891	.998
		1931	43,971,500	73.61	26.39	100	18.95	0.	18.95	7.44	73.61	81.05	.616	.517	1.000
		6 Yr.Av	57,791,500	91.10	8.70	100	4.11	.19	3.92	4.57	91.49	95.89	.780	.824	.998
13	12,150	4 Yr.Av	76,011,125	93.17	46.83	100	7.049	0.	7.049	39.37	53.37	92.94	.349	.599	1.000
		1931	18,983,500	46.46	53.54	100	1.48	0.	1.48	49.58	46.54	98.52	.174	.370	1.000
		5 Yr.Av	59,297,600	88.88	57.52	100	6.34	0.	6.34	41.58	52.08	93.66	.290	.573	1.000
14	14,000	3 Yr.Av	38,355,666	56.65	43.35	100	1.31	.14	1.24	42.04	58.01	98.98	.313	.391	.997
		1931	40,055,000	49.70	50.30	100	10.58	4.68	5.910	39.72	54.93	99.60	.297	.497	.922
		4 Yr.Av	38,714,000	44.76	45.24	100	3.41	1.18	2.23	41.83	55.24	96.59	.316	.579	.978
15	6,400	2 Yr.Av	38,131,950	85.67	14.33	100	4.441	0.	4.441	9.89	85.67	95.56	.501	.585	1.000
		1931	7,860,900	78.97	21.03	100	.69	0.	.69	21.24	78.07	99.31	.140	.190	1.000
		3 Yr.Av	31,974,000	83.14	16.86	100	3.19	0.	3.19	13.67	83.14	96.81	.381	.470	1.000
21	10,000	6 Yr.Av	40,102,042	77.90	22.00	100	2.41	2.06	.44	19.60	80.05	97.90	.571	.732	.974
		1931	18,532,000	56.35	43.65	100	.14	0.	.14	43.51	56.35	99.86	.212	.306	1.000
		7 Yr.Av	45,983,522	76.90	25.10	100	2.19	1.77	.42	22.91	76.67	97.81	.526	.688	.977
22	12,000	7 Yr.Av	31,942,800	78.36	21.63	100	14.97	.596	14.39	6.65	78.96	85.02	.364	.388	.993
		1931	23,619,600	57.13	42.87	100	10.61	0	10.61	12.26	57.13	69.39	.225	.183	1.000
		8 Yr.Av	30,902,400	75.71	24.29	100	14.31	.56	13.42	7.36	75.22	83.02	.354	.369	.994
23	5,000	5 Yr.Av	16,096,400	98.14	1.86	100	1.417	1.417	0.	.44	98.58	98.58	.736	.395	.986
		1931	8,843,000	98.44	1.56	100	.98	.98	0.	0.	100.	98.44	.167	.167	.984
		6 Yr.Av	15,504,167	98.16	1.84	100	1.27	1.27	0.	.27	99.63	98.73	.151	.169	.988
31	20,000	5 Yr.Av	116,910,511	92.58	7.42	100	2.52	.17	2.35	4.891	92.75	97.673	.647	.721	.993
		1931	124,201,600	93.30	6.70	100	2.68	0.	2.68	4.02	93.30	97.32	.701	.751	1.000
		6 Yr.Av	117,880,601	92.63	7.37	100	2.55	.16	2.41	4.75	92.84	97.45	.671	.726	.995
32	20,000	3 Yr.Av	100,425,200	76.07	24.01	100	2.14	0.	2.14	21.89	75.97	97.86	.571	.751	1.000
		1931	34,599,850	65.22	34.78	100	6.40	0.	6.40	28.38	65.22	93.60	.197	.302	1.000
		4 Yr.Av	83,697,863	71.28	28.72	100	3.21	0.	3.21	21.51	71.28	96.79	.478	.619	1.000
33	6,000	7 Yr.Av	26,341,214	68.95	31.05	100	5.78	.25	5.53	25.27	69.20	94.22	.51	.758	.998
		1931	19,606,700	97.57	2.43	100	2.53	0.	2.53	0.	97.47	97.57	.755	.775	1.000
		8 Yr.Av	25,449,500	72.72	27.28	100	5.17	.22	4.95	22.11	72.74	94.61	.547	.760	.998
34	10,000	5 Yr.Av	38,456,687	86.11	13.86	100	4.13	1.17	2.93	9.75	87.11	95.80	.433	.690	.986
		1931	32,044,500	90.26	9.74	100	1.74	0.	1.74	8.00	90.26	98.26	.340	.568	1.000
		6 Yr.Av	37,387,006	88.13	11.87	100	3.55	.98	2.57	8.12	89.11	96.45	.428	.632	.980
35A	12,000	7 Yr.Av	40,844,235	87.64	12.36	100	5.11	.114	5.20	7.05	87.75	94.67	.388	.613	.998
		1931	30,145,800	92.73	10.47	100	4.31	0.	4.31	6.96	92.73	97.69	.287	.527	1.000
		8 Yr.Av	39,057,641	87.81	12.19	100	5.01	.19	4.82	7.34	87.75	94.69	.372	.624	.998
35B	12,000	5 Yr.Av	42,476,400	86.95	13.05	100	4.86	.114	4.77	7.34	86.86	94.11	.463	.645	.998
		1931	36,976,800	87.12	12.88	100	1.01	0.	1.01	11.86	87.12	98.87	.295	.138	1.000
		6 Yr.Av	40,599,800	86.81	13.19	100	5.08	.10	4.98	8.11	86.91	94.92	.385	.444	.999
35C	12,000	3 Yr.Av	43,022,767	92.05	7.94	100	1.19	0.	1.19	4.75	92.25	96.81	.597	.451	.998
		1931	29,934,000	81.50	18.50	100	5.43	0.	5.43	13.07	81.50	94.57	.488	.160	1.000
		4 Yr.Av	34,750,575	89.41	10.59	100	1.75	0.	1.75	8.84	89.41	96.25	.511	.576	.998
36A	14,000	5 Yr.Av	28,715,166	81.16	18.84	100	4.78	.034	4.12	14.66	81.19	95.81	.611	.758	.999
		1931	No Report												
		6 Yr.Av													
36B	15,750	6 Yr.Av	39,456,555	80.39	19.61	100	2.68	.005	2.67	16.93	80.39	97.32	.581	.725	1.000
		1931	51,211,000	68.44	31.56	100	5.75	0.	5.75	25.69	68.44	94.25	.471	.542	1.000
		7 Yr.Av	39,279,618	81.08	18.92	100	3.06	.004	3.12	15.28	81.08	96.88	.553	.688	1.000
36C	25,000	6 Yr.Av	138,028,111	77.03	22.97	100	4.58	.14	4.31	17.60	78.28	95.42	.615	.813	.996
		1931	116,600,000	88.08	11.92	100	4.71	0.	4.71	7.21	88.08	95.96	.531	.601	1.000
		7 Yr.Av	115,609,714	79.38	20.62	100	4.60	.29	4.31	16.02	79.67	95.40	.620	.781	.997
37A	14,000	5 Yr.Av	36,777,179	86.84	13.16	100	4.46	.24	4.22	8.70	87.08	95.54	.707	.810	.992
		1931	No Report												
		6 Yr.Av													
37B	15,750	6 Yr.Av	81,241,711	83.73	16.27	100	2.72	.32	2.39	13.48	83.84	97.22	.586	.696	.997
		1931	77,444,920	80.05	19.95	100	3.97	0.	3.97	15.98	80.05	96.03	.566	.692	1.000
		7 Yr.Av	78,417,888	81.08	18.91	100	2.96	.18	2.75	15.77	81.25	97.38	.568	.693	.997
37C	40,000	2 Yr.Av	95,045,400	63.58	36.50	100	14.57	0.	14.57	41.97	63.58	95.47	.271	.628	1.000
		1931	91,394,000	47.67	52.33	100	11.71	0.	11.71	40.62	47.67	92.38	.062	.158	1.000
		3 Yr.Av	70,758,666	64.18	35.82	100	9.82	0.	9.82	26.36	64.18	96.08	.211	.518	1.000
37D	40,000	2 Yr.Av	84,253,200	92.15	62.65	100	3.67	0.	3.67	58.98	92.35	96.33	.240	.646	1.000
		1931	36,464,650	76.78	23.30	100	8.89	0.	8.89	67.51	76.78	91.11	.031	.128	1.000
		3 Yr.Av	59,816,100	13.47	86.51	100	5.41	0.	5.41	81.12	13.47	94.59	.170	.471	1.000
38	5,000	5 Yr.Av	23,086,999	80.59	19.45	100	2.36	1.40	.96	17.09	81.95	97.64	.527	.654	.9819
		1931	No Report												
		6 Yr.Av													
39	10,000	5 Yr.Av	21,608,800	84.80	15.21	100	1.61	1.45	.16	13.61	86.23	98.39	.247	.251	.982
		1931	14,616,000	98.85	1.15	100	.15	.15	0.	1.00	98.85	99.85	.167	.167	.999
		6 Yr.Av	20,443,340	87.30	12.70	100	1.19	1.03	.16	11.13	88.53	98.81	.214	.228	.985
40	31,000	4 Yr.Av	113,571,000	83.40	16.6	100	5.08	3.71	1.29	11.51	87.05	94.92	.415	.498	.954
		1931	97,884,000	99.84	.16	100	.07	.07	0.	.09	99.93	99.91	.160	.161	.999
		5 Yr.Av	110,434,000	85.69	13.41	100	4.08	2.98	1.10	9.31	90.67	95.92	.484	.473	.961
41A	10,000	3 Yr.Av	26,882,870	72.35	27.74	100	1.97	0.27	1.6	25.97	72.53	98.11	.218	.129	.997
		1931	18,266,000	62.66	37.34	100	0.	0.	0.	37.34	62.66	100	.211	.126	1.000
		4 Yr.Av	20,223,453	69.86	30.14	100	1.46	.20	1.20	28.74	70.06	98.60	.231	.131	.998
41B	20,000	2 Yr.Av	75,831,450	78.49	21.51	100				21.51	78.49	100.00	.433	.551	1.000
		1931	161,887,800	94.65	5.35	100				5.35	94.65	100.00	.983	.836	1.000
		3 Yr.Av	85,183,567	83.88	14.13	100				16.12	83.88	100	.492	.578	1.000
42	17,500	2 Yr.Av	117,798,094	86.51	13.49	100	1.98	0.	1.98	9.38	87.51	96.50	.748	.878	1.000
		1931	72,411,000	82.50	17.50	100	4.36	0.	4.36	13.14	82.50	95.64	.402	.479	1.000
		3 Yr.Av	100,134,396	86.51	13.49	100	1.51	0.	1.51	11.98	86.51	98.48	.696	.812	1.000

TABLE IIIA ANALYSIS OF OUTAGE HOURS FOR REPORT ON MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS BY HYDRAULIC POWER COMMITTEE, P.C.E.A.

VERTICAL TURBINE INSTALLATIONS

Plant Index Number	1			2			3			4			5			6			7			8		
Item / Cause	6 Yr.Av.	1931	7 Yr.Av.	3 Yr.Av.	1931	4 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.
13. GENERAL HYDRAULIC CAUSES:											No Report													
(a) Ice or Trash																			12.34	6.25	11.58			
(b) Floods																								
(c) Penstock or Canal		7.00	1.00	6.84		5.13	3.40		2.98	64.30						40.60		33.83						
(d) Headgates or Intake																			1.86		1.63	28.09		24.58
(e) Other General Hydraulic	3.87		1.32										2.80		2.33	250.20		208.49						
(f) TOTAL GENERAL HYDRAULIC:	3.87	7.00	4.32	6.84		5.13	3.40	0	2.98	64.30			2.80	0	2.33	290.80	0	242.32	14.20	6.25	13.21	28.09	0	24.58
14. WATER WHEELS AND AUXILIARIES:																								
(a) Runner	348.48		298.70		415.92	103.98				0.43			257.30	368.00	276.17		307.00	51.17	146.22	39.67	132.90			
(b) Shut-off Valve																11.80		9.83						
(c) Turbine Gates or Needle Nozzle	.74		.63													5.40		4.50	1.38		1.21			
(d) Guide Bearings or Main Bearings	3.24		2.78		.27	.07	1.86		1.63	2.14						1.60		1.33	142.80	10.00	124.28	5.86		5.13
(e) Thrust Bearing							27.00		23.63	19.86									39.86		34.88	3.43		3.00
(f) Governor and Governor System	19.33	11.83	18.26	6.58	46.35	16.52	1.00	1.00	1.00	1.29			1.00		.83	3.60	78.00	16.00	15.78	13.00	15.43	.78		.68
(g) Pressure Regulator or Deflectors													10.00		8.33	222.40	220.00	222.00	11.64	2.38	10.48	.57		.50
(h) Draft Tube		25.00	3.57				1.57		1.37				107.60	1.00	89.81				1.71		1.50	3.21		2.81
(i) Lubrication System	.25	6.00	1.07	1.63		1.22							20.80	7.00	18.50	4.60	74.00	16.17	9.40	7.90	9.21	.86		.75
(j) Vibration	.73		.63																					
(k) Seal Rings	2.27		1.95													120.20		100.16	10.50		9.19	8.28		7.25
(l) Inspection	5.58	3.83	5.33	2.56	2.13	2.45	1.71		1.50	1.29			4.00		3.33	1.00	3.00	2.00	2.43		2.11	.14		.12
(m) General Overhauling and Replacement	49.60		42.51	5.90		4.43	195.14		170.75	128.08									1.11		0.97			
(n) Other Causes																			40.57	1.55	35.69	113.71		99.50
(o) TOTAL WATER WHEEL:	430.22	46.66	375.43	16.69	464.67	128.67	226.28	1.00	199.88	153.00			401.20	376.00	396.99	371.40	682.00	423.16	421.53	74.50	379.89	136.85	0	119.74
15. GENERATOR AND APPURTENANCES:																								
(a) Vibration																				7.97	1.00			
(b) Lubrication or Oil Leakage		288.50	41.21				66.00		57.75	80.57						77.60		64.66	.41		.36			
(c) Motor or Field				2.69	9.63	4.43				.14						12.60		10.50	21.14		18.50	.93		.81
(d) Armature Iron or Windings																14.40		12.00		3.30	.41			
(e) Exciter and Rheostats	3.25	2.00	3.07	.28		.21	6.19		5.38	.43			1.00	10.00	2.50	2.60		2.17	1.67	1.43	1.55			
(f) Ventilation System																			.84		.75			
(g) Cleaning	1.33	3.00	1.57				12.13		10.61	5.00							67.00	11.17	87.00	123.30	91.54	.14		.12
(h) Inspection	.67		.57	4.57		3.43	10.86		9.50	4.28							25.00	4.17						
(i) Other Causes	2.15		1.84	.44		.33	.14		.12	4.28			.20		.17				60.86	20	53.28	1.06		2.68
(j) TOTAL GENERATOR:	7.40	293.50	48.26	7.97	9.63	8.40	95.28	0.	83.36	94.70			1.20	10.00	2.67	107.20	92.00	104.67	171.84	136.20	147.39	4.13	0	3.61
16. TOTAL ALL CAUSES,- (13+14+15)	441.49	347.16	428.01	31.50	474.30	142.20	327.00	1	286.22	312.00			405.20	386.00	401.99	769.40	774.00	770.15	609.40	216.95	560.47	169.08	0	147.93
17. NUMBER OF UNITS COVERED	2	2	2	2	2	2	1	1	1	1			2	2	2	3	3	3	3	3	3	1	1	1
18. AVERAGE OUTAGE HOURS PER UNIT	220.74	173.58	214.00	15.75	237.15	71.10	327.00	1	286.22	312.00			202.60	193.00	201.00	256.46	258.00	256.72	203.13	72.32	186.82	169.08	0	147.93

TABLE IIIB ANALYSIS OF OUTAGE HOURS FOR REPORT ON MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS BY HYDRAULIC POWER COMMITTEE, P.C.E.A.

VERTICAL TURBINE INSTALLATIONS

Plant Index Number	9			10A			10B			11			12A			12B			13			14			15		
Item / Cause	6 Yr.Av.	1931	7 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.	2 Yr.Av.	1931	3 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	4 Yr.Av.	1931	5 Yr.Av.	3 Yr.Av.	1931	4 Yr.Av.	2 Yr.Av.	1931	3 Yr.Av.
13. GENERAL HYDRAULIC CAUSES:																											
(a) Ice or Trash				3.28		2.07				2.22		1.94															
(b) Floods				55.98		48.98																					
(c) Penstock or Canal	15.07		12.92				4.50		1.00	19.81		17.13	1.55		1.29	2.66	8.00	3.55	297.50		238.00				34.50		23.00
(d) Headgates or Intake	4.00		3.43										.20		.17	1.60		1.33	16.25		13.00						
(e) Other General Hydraulic	40.00		34.29	33.11		28.97																1508.00	1508.00	492.00			
(f) TOTAL GENERAL HYDRAULIC:	59.07	0	50.64	92.37	0	80.82	4.50	0	1.00	22.02	0	19.27	1.75	0	1.46	4.26	8.00	4.88	313.75	0	251.00	0	1508.00	492.00	34.50	0	23.00
14. WATER WHEELS AND AUXILIARIES:																											
(a) Runner	773.82	543.27	740.88				1.50		1.00	13.99		12.24	2.39	200.00	35.33	.71	1781.00	297.43									
(b) Shut-off Valve	66.62	2.33	57.44	30.63		26.80				98.63		86.30	10.67	4.00	9.26	8.20	6.00	7.81									
(c) Turbine Gates or Needle Nozzle	20.70		17.74	.96		.75							2.00		1.74	7.96		6.59	4.75	19.00	7.60						
(d) Guide Bearings or Main Bearings	114.46		98.11	7.10		6.21				6.67		5.84	20.84	21.00	20.07	8.79		7.42	.75		.60				316.50		210.98
(e) Thrust Bearing	5.83		5.00	12.61	31.62	14.99				68.14		59.62	191.25		159.37				1.25		1.00						
(f) Governor and Governor System	8.19	6.17	7.90	1.48		1.30	7.35	17.42	10.71	12.53		10.96	22.45	125.00	10.54	5.61	200.00	38.01	16.25	169.00	46.60				5.00		1.33
(g) Pressure Regulator or Deflectors	.67	6.05	1.04	5.31		4.66				8.80	450.00	63.95	5.31		4.42				517.50	413.00	490.60						
(h) Draft Tube	9.02		7.73	57.95	119.91	65.78				12.85		11.24	1.00	258.00	43.83												
(i) Lubrication System	86.37		74.03							.21		.18	92.33	22.00	80.61	14.43	218.00	48.36	.50	2.00	0.80					20.00	6.67
(j) Vibration				4.55		3.98																					
(k) Seal Rings							4.50		3.00				2.01	4.00	2.34		200.00	33.33									
(l) Inspection	25.34		21.72	4.37	5.96	4.57	8.03	13.35	8.80	4.14	48.00	9.62	6.68	10.00	7.23	5.42	169.00	32.50	11.50		9.20				5.00	5.00	5.00
(m) General Overhauling and Replacement	123.58	1923.96	380.78	120.95	776.62	202.91		152.82	50.94	216.17	137.12	206.39	910.28		758.54				95.00		76.00	(a)					
(n) Other Causes	193.80		58.07	21.96		19.28	1.55		1.37	417.71		378.20	42.40	15.00	42.01	32.03		30.84							■ 20.00		6.67
(o) TOTAL WATER WHEEL:	1338.40	2481.78	1501.74	267.79	934.11	351.06	24.93	183.59	77.82	979.76	635.12	936.75	1314.79	659.00	1205.44	86.01	2473.00	502.19	647.50	602.00	638.40	0	0	0	326.50	45.00	232.65
15. GENERATOR AND APPURTENANCES:																											
(a) Vibration	13.66		11.71																								
(b) Lubrication or Oil Leakage	109.11		93.52	.57		.50				8.57	129.02	23.61					209.00	34.83		8.00	1.60					5.00	1.67
(c) Motor or Field	425.56		364.77	1.14	9.60	2.20	5.67	2.88	4.74	17.75		15.53	9.10	137.00	10.42	1.55		2.96	20.00		15.00				.50		.33
(d) Armature Iron or Windings	222.33		191.00	.28		.25		.65	.22				6.71		5.59	86.20	200.00	105.17	1.50		1.20	194.00		145.50			
(e) Exciter and Rheostats	.62		.57	2.29	-	2.00		8.83	2.94		11.93	1.40	12.41	756.00	14.34	11.81		9.84									
(f) Ventilation System	1.12		.96							1.09		.95	3.97		3.31				8.00		6.40						
(g) Cleaning	321.83		275.85	14.43		12.63				13.42	200.00	36.74	2.30	18.00	4.92	3.88	165.00	30.73								10.00	3.33
(h) Inspection	7.50		6.43	2.02		1.77	8.42		5.65		55.88	6.90	.81		.67	2.62	165.00	29.68	2.25		1.80	(b)			3.50		3.33
(i) Other Causes	18.81		16.14	36.70		31.32	76.60	7.42	59.81	1.40		1.24	.40		.33	1.74		1.45							24.00		16.00
(j) TOTAL GENERATOR:	1121.10	0	960.95	56.52	9.60	50.67	89.64	19.78	86.36	42.33	396.83	86.63	35.71	911.00	181.58	109.82	739.00	214.66	31.75	8.00	27.00	194.00	0	145.50	28.00	15.00	83.66
16. TOTAL ALL CAUSES,- (13+14+15)	2428.57	2481.78	2513.33	417.70	943.71	482.58	119.07	203.37	147.18	1044.16	1031.95	1042.64	1352.25	1570.00	1388.50	202.09	3320.00	721.73	993.00	610.00	916.40	194.00	1808.00	597.50	389.00	60.00	279.31
17. NUMBER OF UNITS COVERED	3	3	3	1	1	1	1	1	1	2	2	2	4	4	4	2	2	2	2	2	2	2	2	2	1	1	1
18. AVERAGE OUTAGE HOURS PER UNIT	809.53	827.26	837.78	417.70	943.71	482.58	119.07	203.37	147.18	522.08	515.98	521.32	338.07	392.50	347.13	101.05	1660.00	360.87	496.50	305.00	458.20	97.00	904.00	298.75	389.00	60.00	279.31

■ In Nov. and Dec. 1931 No.1 Unit had an outage of 503 hours 42 min. for general overhaul, replacement of parts, inspections, etc. - In Oct. and Nov. 1931 No.2 Unit had an outage of 575 hours 25 min.for the same purpose.

■ Construction, preparatory to installation of new unit.
a) All general overhauling and replacement during scheduled idle hours.
b) All inspection during scheduled idle hours.

■ Packing gland

TABLE XA ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

IMPULSE WATER WHEEL INSTALLATIONS

Item — Cause / Plant Index Number	31			32			33			34			35A			35B			35C			36A			36B			36C		
	5 Yr.Av.	1931	6 Yr.Av.	3 Yr.Av.	1931	4 Yr.Av.	7 Yr.Av.	1931	8 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	5 Yr.Av.	1931	5 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	3 Yr.Av.	1931	4 Yr.Av.	5Yr.Av.	1931	6 Yr.Av	6 Yr.Av.	1931	7 Yr.Av.	6 Yr.Av.	1931	7 Yr.Av.
13. GENERAL HYDRAULIC CAUSES:																							No Report							
(a) Ice or Trash							175.71		153.75	6.00		5.00																		
(b) Floods										41.20		34.33																		
(c) Penstock or Canal	.59		.49		8.00	2.00	65.00		56.88							152.60		127.16	24.00		18.00	227.73			84.05	12.78	73.87	18.00		15.43
(d) Headgates or Intake							114.79		100.00																					
(e) Other General Hydraulic										1.60		1.31	29.13															2.39		2.05
(f) TOTAL GENERAL HYDRAULIC:	.59	0	.49		8.00	2.00	355.00	0	310.63	48.80	0	40.64	29.13	0	24.27	152.60	0	127.16	24.00	0	18.00	227.73			84.05	12.78	73.87	20.39	0	17.48
14. WATER WHEELS AND AUXILIARIES:																														
(a) Runner	36.02		30.02	166.54	906.00	351.41	116.00	156.00	121.00				71.46	91.00	74.72	244.53	60.00	213.78	91.67	157.00	158.00	266.79			20.45		17.53	196.84	70.07	180.44
(b) Shut-off Valve	.18		.10	12.30		9.13				10.60		8.81										25.67			28.23	438.10	91.91	29.86	16.67	47.72
(c) Turbine Gates or Needle Nozzle	1.38	12.00	4.82	25.16	52.00	31.97	11.57		10.12	15.10	6.00	10.25	32.50	30.00	32.33	8.00		6.67	16.66	50.00	25.00	27.56			9.18	4.32	8.62	12.02	7.28	11.14
(d) Guide Bearings or Main Bearings	6.80	7.00	6.83	4.52		3.39				55.70	22.00	50.05	29.90	20.00	27.67		5.00	.83				1.84			.76		.65	1.42		1.22
(e) Thrust Bearing											7.00	1.17																		
(f) Governor and Governor System	24.05	40.00	26.71	3.99	5.00	4.24	.14		.12	20.20	10.00	18.50	.80		.67				74.67	20.00	61.00	23.12			9.62		8.25	3.55		3.06
(g) Pressure Regulator or Deflectors	37.56	445.00	105.47	1.54		1.16				35.30	33.00	34.92							3.11		2.50	17.99			3.98		3.41	3.17	7.70	3.11
(h) Draft Tube	11.36		9.47																											
(i) Lubrication System										27.80	18.00	26.17	.60	10.00	3.00	.40		.33												
(j) Vibration																														
(k) Seal Rings																														
(l) Inspection	85.43	50.00	70.43	55.99	104.00	67.99	4.47	7.00	4.87	8.70	1.00	7.42	6.07	50.00	11.30	6.91	14.00	8.11	11.66	28.00	15.75	16.86			9.20	17.78	10.43	10.67	12.15	10.88
(m) General Overhauling and Replacement	166.38		138.99				11.86		10.38	148.00		121.13	219.47		182.88	69.13		57.61				89.81			29.75		25.50	8.37	277.70	41.71
(n) Other Causes								853.00	6.63	1.98		1.62							21.67		16.24	.19			.88	4.31	.87	.72		.62
(o) TOTAL WATER WHEEL:	371.04	554.00	401.54	270.04	1067.00	469.89	144.14	916.00	151.12	345.10	97.00	301.92	362.46	206.00	334.44	129.00	79.00	287.31	219.67	455.00	278.50	444.72			108.18	461.03	158.87	284.25	391.02	299.98
15. GENERATOR AND APPURTENANCES:																														
(a) Vibration	2.62		2.18																											
(b) Lubrication or Oil Leakage										8.80		7.33		20.00	14.31							1.31								
(c) Motor or Field	211.27	13.00	178.23	9.67	6.00	8.75				144.40	10.00	122.00	1.00	1.00	1.17				4.00		1.00				1.46		1.25	1.00		.96
(d) Armature Iron or Windings	2.64		2.08				.86		.75	100.00		91.83	48.60		332.84													54.11		46.57
(e) Exciter and Rheostats	4.68	13.00	5.71	4.13		3.25				4.00		3.33	48.00	30.00	45.88							1.09			.45		.39	.13		.11
(f) Ventilation System	1.60		1.31													23.60		18.83												
(g) Cleaning	32.56	96.00	43.11	18.12		13.59	1.84	4.00	2.11	25.40	11.00	23.13	6.07	57.00	14.56	2.03	5.00	1.28		11.00	2.75	36.20			25.67	2.93	22.43	22.66	1.55	19.93
(h) Inspection	36.14	28.00	34.55		41.00	10.25	1.41	2.00	1.48	16.90	6.00	15.08	.71	50.00	15.44	.27	6.00	1.23		10.00	2.50	16.39			14.00		12.00	10.99		9.62
(i) Other Causes	2.36		1.92	41.65		31.24	1.71		1.25	10.00		8.33	12.66		10.00	8.26		6.83				10.13			.66		.57	.96		.82
(j) TOTAL GENERATOR:	293.82	150.00	268.67	73.77	47.00	67.08	7.86	6.00	7.61	326.10	33.00	277.43	539.00	193.00	432.15	34.00	11.00	30.17	4.00	21.00	8.25	59.11			42.24	2.93	36.63	90.07	1.55	77.71
16. TOTAL ALL CAUSES,- (13+14+15)	665.64	704.00	668.70	343.81	1122.00	538.37	507.00	222.00	471.36	720.20	130.00	621.81	928.53	404.00	841.08	515.87	90.00	444.88	247.66	476.00	304.75	731.56			234.48	478.74	269.37	395.11	395.37	395.13
17. NUMBER OF UNITS COVERED	3	3	3	2	2	2	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	2			1	1	1	1	1	1
18. AVERAGE OUTAGE HOURS PER UNIT	220.55	235.00	222.90	171.90	561.00	269.19	507.00	222.00	471.36	360.10	65.00	310.91	464.27	202.00	420.54	515.87	90.00	444.88	247.66	476.00	304.75	365.78			234.48	478.74	269.37	395.11	395.37	395.13

m Cut over to semi-automatic

TABLE XB ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

IMPULSE WATER WHEEL INSTALLATIONS

Item — Cause / Plant Index Number	37A			37B			37C			37D			38			39			40			41A			41B			42		
	6 Yr.Av.	1931	7 Yr.Av.	6 Yr.Av.	1931	7 Yr.Av.	2 Yr.Av.	1931	3 Yr.Av.	2 Yr.Av.	1931	3 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	5 Yr.Av.	1931	6 Yr.Av.	4 Yr.Av.	1931	5 Yr.Av.	3 Yr.Av.	1931	6 Yr.Av.	2 Yr.Av.	1931	3 Yr.Av.	2 Yr.Av.	1931	3 Yr.Av.
13. GENERAL HYDRAULIC CAUSES:																														
(a) Ice or Trash	1.84	No. Report		1.89		1.62								No Report																
(b) Floods																														
(c) Penstock or Canal	129.33			130.04		111.46	5.50		1.67	5.50		1.67	315.19						43.99		11.19	161.00		120.75				21.05	11.00	17.70
(d) Headgates or Intake	3.35												2.68			16.27		13.56												
(e) Other General Hydraulic	2.84			5.66		4.84													1.70		1.36							20.86	4.05	4.05
(f) TOTAL GENERAL HYDRAULIC:	135.76			137.59	0	117.91	5.50	0	1.67	5.50	0	1.67	320.07			16.27		13.56	45.69	0	12.55	161.00	0	120.75	0	0	0	21.05	31.05	21.75
14. WATER WHEELS AND AUXILIARIES:																														
(a) Runner	227.52			17.30	1.56	15.13	881.83		587.89	7.41		5.07	132.72						29.50		23.60							67.33	2.25	45.64
(b) Shut-off Valve	7.06			6.31	16.73	7.71	64.12		42.76	37.00	20.48	31.40	1.46																	
(c) Turbine Gates or Needle Nozzle	22.77			32.62		27.56	4.50		1.00	27.28		18.19	40.91			48.38		40.32	7.25		5.80						91.90		61.20
(d) Guide Bearings or Main Bearings	5.17						38.81	1.92	25.98				4.68			8.64		7.20									14.45		9.63
(e) Thrust Bearing											.67	.22																		
(f) Governor and Governor System	16.71			13.44		16.26	24.36	6.80	18.51	13.25		8.83	30.73			.95		.79	.25		.20						21.75		14.50
(g) Pressure Regulator or Deflectors	.73			7.16		6.16				3.00		2.00	4.16						25.25		20.20								
(h) Draft Tube										7.00		4.67																		
(i) Lubrication System																														
(j) Vibration																														
(k) Seal Rings																														
(l) Inspection	48.31			23.57	1.73	22.31	9.84		6.56	10.05		6.70	2.46			.40	m 5.85	1.31	.50		.40						119.64	80.32	106.52
(m) General Overhauling and Replacement	37.45			114.26	610.57	184.04				132.00		90.66	123.43										m			m		18.00		18.00
(n) Other Causes	62.35			62.45		18.21	34.00		22.77	77.23		51.16				.40		.33	99.87		79.90						132.97	82.57	249.50
(o) TOTAL WATER WHEEL:	402.13			240.57	629.99	298.70	1056.70	8.72	707.32	283.52	21.15	172.99	340.42			58.77	5.85	49.95	162.62		130.10	0	0	0	0	0	0			
15. GENERATOR AND APPURTENANCES:																														
(a) Vibration							21.84		14.56																					
(b) Lubrication or Oil Leakage																														
(c) Motor or Field	36.14			5.37		4.60	130.12	830.33	363.52	4.81	720.72	243.45	19.94						2.62	6.38	1.37							400.75		267.14
(d) Armature Iron or Windings	144.11			5.38		4.61		214.95	78.32				71.60			11.98		9.98	110.00		88.00								
(e) Exciter and Rheostats	.32			0.32	52.17	7.73					6.70	2.21	.20			10.78		8.98												
(f) Ventilation System																														
(g) Cleaning	27.11			46.79		40.11							29.62			11.42	7.15	9.82	7.50		6.00						80.45	1248.00	469.43
(h) Inspection	56.91			29.67		25.43	4.09		2.71	4.01		3.27	11.23			1.71		1.47				a)			a)		250.38	161.58	221.41
(i) Other Causes	31.62			11.35		11.48	54.06		36.04	57.14		46.59	13.29			.27		.23												
(j) TOTAL GENERATOR:	276.29			100.88	52.17	93.92	210.11	1045.28	495.17	64.86	727.42	287.03	167.09			14.45	7.15	29.50	231.87	6.38	186.77	0	0	0	0	0	0	731.02	1411.58	957.98
16. TOTAL ALL CAUSES,- (13+14+15)	818.16			479.04	696.16	510.05	1272.31	1074.00	1206.20	321.28	748.57	463.70	828.38			109.48	13.00	93.41	410.18	6.38	329.42	161.00	0	120.75	0	0	0	1085.25	1526.00	1232.13
17. NUMBER OF UNITS COVERED	2			2	2	2	1	1	1	1	1	1	4			1	1	1	1	1	1	1	1	1	1	1	1	4	4	4
18. AVERAGE OUTAGE HOURS PER UNIT	409.08			239.52	348.08	255.03	1272.31	1074.00	1206.20	321.28	748.57	463.70	207.09			109.48	13.00	93.41	410.18	6.38	329.42	161.00	0	120.75	0	0	0	271.32	381.50	308.03

n Wheel Pit and Needle

m All general overhauling and replacement during scheduled idle hours.
a) All inspection during scheduled idle hours.

TABLE VI ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

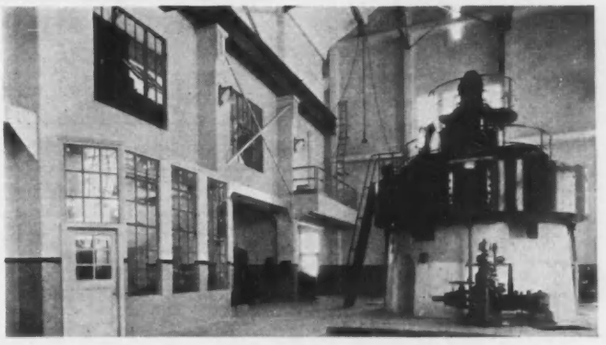
	VERTICAL TURBINES			IMPULSE WATER WHEELS			HORIZONTAL TURBINES			ALL HYDRO-ELECTRIC UNITS		
	HOURS			HOURS			HOURS			HOURS		
Item Cause	1930 Total	1931	1931 Total	1930 Total	1931	1931 Total	1930 Total	1931	1931 Total	1930 Total	1931	1931 Total
13. GENERAL HYDRAULIC CAUSES:												
(a) Ice or Trash	131.90	6.25	138.15	1283.06	0	1283.06	6.25	0	6.25	1421.21	6.25	1427.46
(b) Floods	0	0	0	30.00	0	30.00	0	0	0	30.00	0	30.00
(c) Penstock or Canal	2622.95	15.00	2637.95	7480.24	31.78	7512.02	6013.50	2647.00	8660.50	16116.69	2693.78	18810.47
(d) Headgates or Intake	307.66	0	307.66	926.83	0	926.83	12.00	0	12.00	1246.49	0	1246.49
(e) Other General Hydraulic	1760.00	1808.00	3568.00	253.60	20.86	274.45	48.78	3.16	51.94	2062.38	1832.01	3894.39
(f) TOTAL GENERAL HYDRAULIC:	4822.51	1829.25	6651.76	9973.73	52.63	10026.36	6080.53	2650.16	8730.69	20876.77	4532.04	25408.81
14. WATER WHEELS AND AUXILIARIES:												
(a) Runner	9170.99	3654.86	12825.85	10161.03	1643.88	11804.91	222.20	34.00	256.20	19554.22	5332.74	24886.96
(b) Shut-off Valve	1457.93	12.33	1470.26	845.08	491.98	1337.06	30.47	0	30.47	2333.48	504.31	2837.79
(c) Turbine Gates or Needle Nozzle	240.17	19.00	259.17	1952.41	161.60	2114.01	2.50	4.00	6.50	2195.08	184.60	2379.68
(d) Guide Bearings or Main Bearings	2663.98	31.27	2695.25	715.75	55.92	771.67	319.02	7.30	326.32	3698.75	94.49	3793.24
(e) Thrust Bearing	2192.58	31.62	2224.20	0	7.67	7.67	23.00	0	23.00	2215.58	39.29	2254.87
(f) Governor and Governor System	682.79	666.77	1349.56	1158.67	81.80	1240.47	66.85	6.40	73.25	1908.31	754.97	2663.28
(g) Pressure Regulator or Deflectors	3446.52	1091.43	4537.95	674.99	485.78	1160.77	1099.12	0	1099.12	5220.63	1577.21	6797.84
(h) Draft Tube	1138.25	403.91	1542.16	56.80	0	56.80	1.25	4.00	5.25	1196.30	407.91	1604.21
(i) Lubrication System	1260.61	356.90	1617.51	158.00	33.00	191.00	7.85	0	7.85	1426.46	389.90	1816.36
(j) Vibration	36.28	0	36.28	0	0	0	3.00	0	3.00	39.28	0	39.28
(k) Seal Rings	780.59	204.00	984.59	0	0	0	252.85	6.42	259.27	1033.44	210.42	1243.86
(l) Inspection	468.69	259.27	727.96	1768.48	384.83	2153.31	32.60	9.75	42.35	2269.77	653.85	2923.62
(m) General Overhauling and Replacement	10617.99	2990.52	13608.51	5530.87	888.75	6419.62	2180.00	0	2180.00	18328.86	3879.27	22208.13
(n) Other Causes	6060.53	36.55	6097.08	915.01	55.83	970.84	96.63	0	96.63	7072.17	92.38	7164.55
(o) TOTAL WATER WHEEL:	40217.90	9758.43	49976.33	30937.09	4291.04	35228.13	4337.34	71.87	4409.21	78492.33	14121.34	92613.67
15. GENERATOR AND APPURTENANCES:												
(a) Vibration	82.00	7.97	89.97	56.75	0	56.75	0	0		138.75	7.97	146.72
(b) Lubrication or Oil Leakage	2135.55	639.52	2775.07	50.55	20.00	70.55	0	0		2186.10	659.52	2845.62
(c) Motor or Field	3071.25	159.11	3230.36	1346.46	1587.43	4933.89	21.60	5.83	27.43	6439.31	1752.37	8191.68
(d) Armature Iron or Windings	2463.55	803.95	2867.50	4950.03	234.95	5184.98	1830.44	0	1830.44	9244.02	438.90	9682.92
(e) Exciter and Rheostats	236.51	790.19	1026.70	431.03	105.87	536.90	21.91	0	21.91	689.45	896.06	1585.51
(f) Ventilation System	72.22	0	72.22	121.00	0	121.00	91.32	0	91.32	284.54	0	284.54
(g) Cleaning	2354.96	586.30	2941.26	1712.20	1440.48	3152.68	17.00	0	17.00	4084.16	2026.78	6110.94
(h) Inspection	251.90	245.88	497.78	1588.99	353.73	1942.72	2.61	27	2.88	1843.50	599.88	2443.38
(i) Other Causes	1331.72	7.62	1339.34	1410.77	0	1410.77	11.27	25.93	37.20	2754.26	33.55	2787.81
(j) TOTAL GENERATOR:	11999.66	2640.54	14640.20	13667.78	3742.46	17410.24	1996.65	32.03	2028.68	27664.09	6415.03	34079.12
16. TOTAL ALL CAUSES.- (13+14+15)	57040.07	14228.22	71268.29	47578.60	8086.13	55664.73	12414.52	2754.06	15168.58	117033.19	25068.41	142101.60
17. NUMBER OF UNITS COVERED												
18. AVERAGE OUTAGE HOURS PER UNIT												

TABLE VII ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

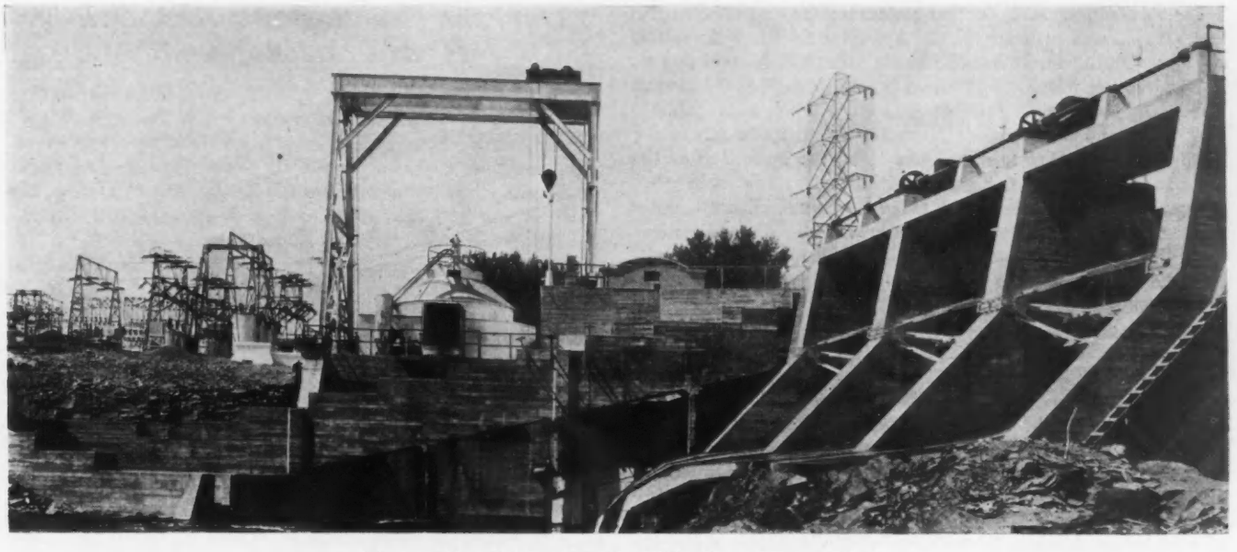
	VERTICAL TURBINES			IMPULSE WATER WHEELS			HORIZONTAL TURBINES			ALL HYDRO-ELECTRIC UNITS		
	PERCENT			PERCENT			PERCENT			PERCENT		
Item Cause	1930 Total	1931	1931 Total	1930 Total	1931	1931 Total	1930 Total	1931	1931 Total	1930 Total	1930	1931 Total
13. GENERAL HYDRAULIC CAUSES:												
(a) Ice or Trash	.231	.044	.194	2.697	0.	2.305	.050	0.	.041	1.214	.025	1.005
(b) Floods	0.	0.	0.	.063	0.	.054	0.	0.	0.	.026	0.	.021
(c) Penstock or Canal	4.598	.105	3.701	15.722	.393	13.495	48.439	96.113	57.095	13.771	10.746	13.237
(d) Headgates or Intake	.539	0.	.432	1.948	0.	1.665	.097	0.	.079	1.065	0.	.877
(e) Other General Hydraulic	3.085	12.707	5.006	.533	.258	.493	.393	.115	.342	1.762	7.308	2.741
(f) TOTAL GENERAL HYDRAULIC:	8.455	12.856	9.333	20.963	.651	18.012	48.979	96.228	57.557	17.838	18.079	17.881
14. WATER WHEELS AND AUXILIARIES:												
(a) Runner	16.078	25.687	17.997	21.356	20.330	21.207	1.790	1.235	1.689	16.708	21.273	17.513
(b) Shut-off Valve	2.556	.087	2.063	1.776	6.084	2.402	.245	0.	.201	1.994	2.012	1.997
(c) Turbine Gates or Needle Nozzle	.421	.134	.364	4.103	1.998	3.798	.020	.145	.043	1.876	.736	1.675
(d) Guide Bearings or Main Bearings	4.670	.220	3.782	1.504	.692	1.386	2.570	.265	2.151	3.160	.377	2.669
(e) Thrust Bearing	3.844	.222	3.121	0.	.095	.014	.185	0.	.152	1.893	.157	1.587
(f) Governor and Governor System	1.197	4.686	1.894	2.435	1.012	2.228	.538	.232	.483	1.631	3.012	1.874
(g) Pressure Regulator or Deflectors	6.042	7.671	6.367	1.419	6.008	2.085	8.853	0.	7.246	4.461	6.292	4.784
(h) Draft Tube	1.995	2.839	2.164	.119	0.	.102	.010	.145	.035	1.022	1.627	1.129
(i) Lubrication System	2.210	2.508	2.270	.332	.408	.343	.063	0.	.052	1.219	1.555	1.278
(j) Vibration	.064	0.	.051	0.	0.	0.	.024	0.	.020	.034	0.	.028
(k) Seal Rings	1.368	1.434	1.382	0.	0.	0.	2.037	.233	1.709	.883	.839	.875
(l) Inspection	.822	1.822	1.021	3.717	4.759	3.868	.263	.354	.279	1.939	2.608	2.057
(m) General Overhauling and Replacement	18.615	21.018	19.095	11.625	10.991	11.533	17.560	0.	14.372	15.661	15.475	15.628
(n) Other Causes	10.625	.257	8.555	1.923	.690	1.744	.778	0.	.637	6.043	.369	5.042
(o) TOTAL WATER WHEEL:	70.508	68.585	70.126	50.311	53.067	50.710	34.938	2.609	29.069	58.524	56.332	58.136
15. GENERATOR AND APPURTENANCES:												
(a) Vibration	.144	.056	.126	.119	0.	.102	0.	0.	0.	.119	.032	.103
(b) Lubrication or Oil Leakage	3.744	4.495	3.894	.106	.247	.127	0.	0.	0.	1.868	2.631	2.003
(c) Motor or Field	5.384	1.118	4.531	7.033	19.632	8.864	.174	.212	.181	5.502	6.990	5.765
(d) Armature Iron or Windings	4.319	1.433	3.743	10.404	2.906	9.315	14.744	0.	12.067	7.899	1.751	6.814
(e) Exciter and Rheostats	.415	5.554	1.441	.906	1.309	.965	.176	0.	.144	.589	3.574	1.116
(f) Ventilation System	.127	0.	.101	.254	0.	.217	.736	0.	.602	.243	0.	.200
(g) Cleaning	4.129	4.121	4.127	3.599	17.814	5.664	1.137	0.	.112	3.490	8.085	4.300
(h) Inspection	.442	1.728	.698	3.340	4.374	3.490	.021	.010	.019	1.575	2.393	1.719
(i) Other Causes	2.335	.054	1.878	2.966	0.	2.534	.095	.941	.249	2.353	.133	1.963
(j) TOTAL GENERATOR:	21.037	18.559	20.541	28.727	46.282	31.278	16.083	1.163	13.374	23.638	25.589	23.983
16. TOTAL ALL CAUSES.- (13+14+15)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
17. NUMBER OF UNITS COVERED												
18. AVERAGE OUTAGE HOURS PER UNIT												

SUPPLEMENT TO TABLES III, IV, AND V—OUTAGE HOURS IN EXCESS OF 100 HOURS

Item		Plant Index No.	Outage Hours	Cause
13	General hydraulic causes			
(e)	Other general hydraulic	14	1,808	Construction preparatory to installation of a new unit.
(c)	Penstock or canal	22	2,647	Construction—enlarging canal.
14	Waterwheels and auxiliaries			
(a)	Runner	12A	200	Brackets—general overhauling.
(a)	Runner	12B	1,781	Build up and face runners and guide vanes.
(a)	Runner	32	906	Install new buckets.
(a)	Runner	5	368	Build up and face runners and guide vanes.
(a)	Runner	6	307	Build up and face runners and guide vanes.
(a)	Runner	33	156	Install new buckets.
(a)	Runner	35C	357	Install new buckets.
(a)	Runner	2	415.9	Caused by 12-inch piece of drill steel, accidentally dropped into upper end of penstock, lodging in runner. Wickets and runner badly hammered. Unit shut down, repaired and pits in runner filled at same time.
(f)	Governor and governor system	12A	125	General overhauling.
(f)	Governor and governor system	12B	200	General overhauling.
(f)	Governor and governor system	13	168	General overhauling.
(g)	Pressure regulators	13	413	Overhaul and test relief valve.
(g)	Pressure regulators	6	220	Overhaul and plate steel with copper.
(g)	Pressure regulators	31	445	Overhaul relief valves (Alemite system).
(h)	Draft tube	12A	258	Lining tube.
(i)	Lubrication system	12B	218	Stopping leaks.
(k)	Seal rings	12B	200	New seal rings.
(1)	Inspection	12B	168	Inspection.
(1)	Inspection	32	104	Inspection.
15	Generator and appurtenances			
(b)	Lubrication or oil leakage	12B	209	Stopping leaks.
(b)	Lubrication or oil leakage	1	288.5	Leakage of bearing lubrication piping. Piping taken apart, threads tinned and sweated in place. Packed joint was made where pipes enter bearing reservoirs.
(c)	Rotor or field	12A	137	Painting, wedging coils, etc.
(d)	Armature iron or windings	12B	200	Neutral brought out.
(e)	Exciter and rheostats	12A	756	General overhauling of exciters.
(g)	Cleaning	12B	165	General cleaning.
(g)	Cleaning	7	123.3	Cleaning rotor, stator, coils and ventilating ducts. Retaping and varnishing.
(g)	Cleaning	42	124.8	General cleaning (this would have been deferred if sufficient water had been available for normal operation.)
(h)	Inspection	12B	165	General inspection.



Salt Springs power house (upper) and Tiger Creek plant (lower)



First outdoor hydro plant in California at Merced Falls

TABLE VIII.-INDEX TO HYDRO-ELECTRIC PLANTS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

INDEX NO.	COMPANY	PLANT	WATERWHEEL MANUFACTURER	GENERATOR MANUFACTURER
		VERTICAL TURBINES		
1	California Oregon Power Co.	Copco No.2	Allis-Chalmers	Westinghouse
2	California Oregon Power Co.	Prospect No.2	Pelton	General Electric
3	Pacific Gas & Electric Co.	Hat Creek No.1	Wellman-Seaver-Morgan	General Electric
4	Pacific Gas & Electric Co.	Hat Creek No.2	Wellman-Seaver-Morgan	General Electric
5	Pacific Gas & Electric Co.	Pit River No.1	Allis-Chalmers	Allis-Chalmers
6	Pacific Gas & Electric Co.	Pit River No.3	Pelton	General Electric
7	San Joaquin Light & Power Corp.	Kerckhoff	Allis-Chalmers	Allis-Chalmers
8	San Joaquin Light & Power Corp.	Kern Canyon	Allis-Chalmers	Allis-Chalmers
9	Southern California Edison Co.	Big Creek No.3	Wellman-Seaver-Morgan	Westinghouse
10A	Southern California Edison Co.	Big Creek No.8-Unit 1	I.P. Morris	General Electric
10B	Southern California Edison Co.	Big Creek No.8-Unit 2	Pelton	General Electric
11	Southern California Edison Co.	Kern River No.3	Pelton	General Electric
12A	Pacific Gas & Electric Co.	Big Bend-Units 1,2,3,4	I.P.Morris	General Electric
12B	Pacific Gas & Electric Co.	Big Bend-Units 5, & 6	I.P.Morris	General Electric
13	Pacific Gas & Electric Co.	Melones	S.Morgan Smith	Westinghouse
14	Bureau of Power & Light	San Francisquito No.2	Wellman-Seaver-Morgan	General Electric
15	Pacific Gas & Electric Co.	Spaulding No.1	Pelton	General Electric
		HORIZONTAL TURBINES		
21	California Oregon Power Co.	Copco No.1	Allis-Chalmers	General Electric
22	Pacific Gas & Electric Co.	Wise	Pelton	Westinghouse
23	Southern Sierras Power Co.	Adams Main	Worthington	General Electric
		IMPULSE WATERWHEELS		
31	Pacific Gas & Electric Co.	Caribou	Allis-Chalmers	General Electric
32	Pacific Gas & Electric Co.	Feather River	Pelton	General Electric
33	Pacific Gas & Electric Co.	Spring Gap	Pelton	General Electric
34	Pacific Gas & Electric Co.	El Dorado	Allis-Chalmers	General Electric
35A	Pacific Gas & Electric Co.	Drum - Units 1 & 2	Pelton	Westinghouse
35B	Pacific Gas & Electric Co.	Drum - Unit 3	Pelton	Westinghouse
35C	Pacific Gas & Electric Co.	Drum - Unit 4	Pelton	Allis-Chalmers
36A	Southern California Edison Co.	Big Creek No.1-Unit 1,2	Allis-Chalmers	General Electric
36B	Southern California Edison Co.	Big Creek No.1 Unit 3	Allis-Chalmers	General Electric
36C	Southern California Edison Co.	Big Creek No.1 Unit 4	Pelton	Westinghouse
37A	Southern California Edison Co.	Big Creek No.2 Unit 3,4	Allis-Chalmers	Westinghouse
37B	Southern California Edison Co.	Big Creek No.2 Unit 5,6	Pelton	Westinghouse
37C	Southern California Edison Co.	Big Creek No.2A Unit 1	Allis-Chalmers	Westinghouse
37D	Southern California Edison Co.	Big Creek No.2A Unit 2	Pelton	Westinghouse
38	Southern California Edison Co.	Kern River No.1	Allis-Chalmers	General Electric
39	Southern Sierras Power Co.	Poole	Pelton	General Electric
40	San Joaquin Light & Power Corp.	Balch	Allis-Chalmers	General Electric
41A	Bureau of Power & Light - Unit #4	San Francisquito No.1	Pelton	Westinghouse
41B	Bureau of Power & Light - Unit #5	San Francisquito No.1	Allis-Chalmers	Allis-Chalmers
42	Hetch Hetchy Water Supply	Moccasin	Pelton	General Electric

The horizontal turbines range in size from 7,500 hp. to 20,000 hp., and average 16,175 hp. Speeds vary from 200 r.p.m. to 400 r.p.m. and static heads from 125 ft. to 245.4 ft.

The impulse wheels range from 9,500 hp. to 56,000 hp. with an average of 26,392 hp. Speeds vary from 143 r.p.m. to 514 r.p.m. and static heads from 930 ft. to 2,563 ft.

The accompanying tabular data show the operation of the units for the year 1931, together with the previous seven years of operation and present the total and average kilowatt-hours generated as well as the segregated outage hours listed in accordance with the cause of outage. Brief footnotes indicate the nature of some of the unusual outages and the supplementary sheet indicates a detailed explanation of most of the outage hours of over 100-hr. duration. The report is well worth the time required for its complete study and affords an illuminating insight into the reasons for outages. It is interesting to note that for this year 1931 the average outage time, when in demand, is practically zero. Some outages are of a minor nature but frequently recurring, others are major casualties. The former are generally subject to correction when their nature is determined, with a resulting better performance of equipment. The latter cannot usually be forestalled, but are in the nature of unforeseen accidents which are unpreventable.

*Current Practice and Research in Hydro Development**

The principal function of this committee is to find where any research or investigation is being made by the operating companies, what new developments in engineering or operating methods are being used or developed and to serve as a clearing house for this information, to the end that all member companies can directly benefit from the collective experience of all.

This subcommittee was first formed during the year 1928-29, but dealt only with the subject of research. In 1929-30 the subject of current practice was added to its duties.

This information is collected continuously, it being unnecessary to wait until any study is completed before the data are made available.

THE following items have been submitted for report to the research section of this subcommittee:

* Report of subcommittee on current practice and research in hydro development, hydraulic power committee, Engineering Section. J. F. Davenport, chairman. T. J. Corwin, H. E. Fuqua, F. R. Harp, R. S. Quick, H. S. Warren, Geo. M. Wills.

General Comments on Electrical Features[1]

IN INVESTIGATING economies in electrical developments, it is felt that the current practice and research subcommittee of the hydraulic power committee should not confine its activities to economies in connection with hydraulic plant alone.

If the hydraulic plant alone is considered, even if the step-up station be also included, the electrical equipment will be generally so small a percentage of the total cost of the plant that any reduction in the cost of this part of the equipment would be lost when compared to the cost of the whole.

In comparing the cost of hydro and steam power, a more satisfactory analysis will result from a consideration of the cost of hydro power per unit delivered in the load area, rather than to confine the investigation to the cost of the hydro-electric development alone.

If this view be adopted, the cost of power so delivered should include, besides the generating plant, costs of electrical equipment and step-up substation, transmission, and possibly some step-down equipment. On this basis, not only does the electrical equipment become a larger percentage of the total investment, but the possibility of varying the magnitude of the investment in the electrical equipment itself becomes greater.

The transmission cost per kilowatt for a given transmission equipment is at its lowest when the equipment is worked at its maximum capacity continuously. This is a condition which has never been practically attained on any transmission system. Any improvement in operating practices or system design which would permit a major improvement in the load factor of a transmission line would make a recognizable reduction in the delivered cost per kilowatt of power over the line.

In many modern hydro transmission projects, the power limit for the line is the system stability limit. If it is planned, from an operating standpoint, to clear faults on this transmission system without any generating loss, the power limit of the line will then be the transient stability power limit. If, on the other hand, it were decided to lose the generation with the line in the event of any disturbance on the line, it might be feasible to operate the line to a value approaching the limit of stability, which in general would be appreciably higher than the transient power limit. In this event, the output of the line in kw-hr. per year might be appreciably increased and the transmission cost reduced.

If we now consider cost, not in terms of first cost, but in cost per kilowatt of power generated, the efficiency of the equipment and the operating maintenance expense of the electrical equipment are involved.

From an operating standpoint, it is, of course, feasible under some conditions to substitute automatic control for operators, wholly or in part, and to make some modest reduction in this factor.

The recent trend toward reduction in plant investment by the use of outdoor machines is an example of an attempt on the part of the electrical group to make some progress in this direction.

Simplification of Station Design

The major trend in the design of hydro-electric stations appears to be toward the simplification of station design, with its subsequent reduction in the cost of power. Along this line, there is an increasing tendency to construct generating stations of the semi-outdoor type.

Pumped Storage Plants

Hydraulic regeneration or pumped storage plants have continued to receive considerable study. Heretofore, the general practice in pumped storage plants has been to use two separate hydraulic units, one for pumping and one for generating, both connected on the same shaft with an electrical unit, which serves as either a generator or motor. This arrangement has been particularly popular in Europe. On the other hand, a few installations, such as at Rocky River, Conn., have been provided with complete separate hydraulic and electrical units. A more recent development makes use of a two-speed combined pumping and generating unit, which will be briefly discussed.

Since the maximum efficiency of a pump occurs at a speed only a few per cent above that at which pumping starts, the efficiency curve breaks very sharply when the speed is reduced. Therefore, the pumping speed for any design of runner is quite definitely fixed.

Should the unit operate as a turbine, running at the same r.p.m. as that used for pumping, but in the opposite direction, the efficiency of the turbine will be at least 5 per cent and sometimes as much as 10 per cent lower than the efficiency that it would be possible to obtain if the speed were lowered somewhat. This difference in efficiency practically precludes the use of a 1-to-1 speed ratio for the pumping and generating operation, where the same head exists in each case.

It is believed, therefore, that two-speed units will be necessary for the exploitation of most pumping projects, but that in each case the evaluation placed on the improved efficiency as compared with the extra cost of the two-speed unit should be made. From the data that are now available, it appears that a speed ratio of 5 to 4 will cover most developments.

The records of tests which have been made on two-speed electrical models indicate that the voltage wave shape on full sized units will be reasonably comparable with standard machines of similar size and rating.

Practically all hydraulic power is transmitted over overhead transmission lines. In line with this same subject of improving the reliability of transmission lines, has been the development of increased switching speed. This has been brought about by faster oil circuit breakers and their controlling relays, which in many instances permit a faulty line to be switched out with a minimum disturbance on the system.

Quick Response Excitation[2]

THE question of quick-response excitation was briefly discussed by the committee, as well as the use of a storage battery instead of a pilot exciter.

The opinion of the Westinghouse engineers is that, in nearly every case involving a new installation, it will be more convenient to equip the generator with a direct-connected main and pilot exciter, the pilot exciter usually being small in comparison with other machines and involving little difficulty.

For converting a present installation to quick-response excitation, on the other hand, the use of a storage battery in place of the pilot exciter may be very desirable. There are no objections to the use of a storage battery in place of a pilot exciter, if it proves more desirable and economical. This will depend, of course, to some extent on the difficulty which would be encountered in mounting a pilot exciter on the existing machine. Mechanical drives in this case may not be very desirable and may be too expensive. From the electrical standpoint, the two methods are essentially equivalent, since each serves to provide a source of constant voltage for separate excitation of the main exciter.

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[1] Paper prepared by H. E. Fuqua for subcommittee on current practice and research, hydraulic power committee.

[2] Paper prepared by A. S. Warren for subcommittee on current practice and research, hydraulic power committee.

Tests Conducted at Big Creek No. 1 With Experimental Nozzle and Needle Parts at Penstock Pressures[3]

THE purpose of the tests was to determine, if possible, which of the existing designs of impulse turbine nozzles gave the best power jet, and to get indications of improvements which could be made in the designs to increase the efficiency of the turbines.

The nozzle body was machined from a steel blank to scale of nozzle piece at Big Creek No. 1. The inner contour of the nozzle was machined by holding the blank in a special angle-plate jig, clamped to the face-place of a 24-in. lathe. A smooth bore was secured, although it was a tedious process boring through a 30-deg. arc. (See Fig. 1.)

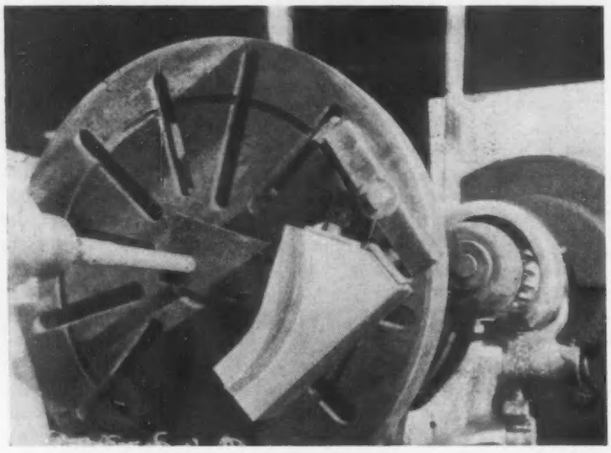

Fig. 1—A smooth bore was secured, although it was a tedious process boring through a 30-deg. arc

The different nozzle tips were machined and polished from brass stock to templates made from the original scaled drawings. These were screwed into the nozzle body by a spanner wrench, which made a very easy way to change tips. Fig. 2 shows a typical experimental needle and nozzle design.

The needle and guide sleeves were easily changed by removing the needle mechanism from the nozzle body, inserting the proper sleeve and needle, and replacing the needle mechanism.

The nozzle was mounted on a concrete foundation in the basement oil pump room of power house No. 1, and directed to discharge through a sluice gate out into the power house No. 1 afterbay. The nozzle was supplied by a 2-in. line from the exciter header. The run of 2-in. pipe had four right-angle bends and was about 70 ft. in length. The maximum flow was a little under 0.8 sec.-ft.

The flow indication was secured by a mercury manometer connected to a venturi tube in the straight section of the 2-in. line at about 7 ft. from the nozzle.

When a test run was made, the manometer was read by an experienced machinist using a special scale, who also calipered the jet with calipers having needle points. Another observer secured pressure readings with a Crosby pressure scale at two points on the nozzle. A third observer checked the readings and recorded them. The needle mechanism handwheel was indexed so that the stroke or opening could be read from it. After all readings were made, photographing lights were turned on and a picture taken of the jet, manometer, and two indicating pressure gages.

The set giving maximum discharge was run, first with the stroke decreased in approximately equal steps from wide open. The tests with other nozzles were run open and then set to similar flows to the first tests for the remaining steps, so that a series of pictures of different nozzles discharging the same flow could be secured for direct comparisons.

Each photograph was given a serial number.

Each photograph was marked with three lines: the first at edge of orifice, the second marked center line (A), indicating center line of a waterwheel of standard design scaled to proportions of the jet from the units at Big Creek No. 1, and the third marked center line (B), indicating the center line of a waterwheel of different manufacture at Big Creek No. 1. Table I shows tabulated results for tests 32-39 on which nozzle parts shown in Fig. 2 were used.

An indication of how much the various jets broom from the point of *vena contracta* through these points is given in the tabulation under relative diameter of jets. In each case the diameter at the *vena contracta* is taken as 1.0 and the relative diameters of the other two points are expressed as ratios to the diameter at *vena contracta*.

The sec.ft. is expressed as relative flow in per cent to the maximum flow. This was done in order that it would be unnecessary to calibrate the venturi tube with great accuracy in order to express the flow in fractions of a sec.ft.

The per cent wide-open flow is the ratio of the flow of the test to wide-open flow of the nozzle being tested. The per cent wide-open stroke and the per cent wide-open flow gives an indication of the flow stroke cutoff, which for good speed regulation should be constant.

The diameter of the jet in inches is the calipered diameter made with needle-point calipers at the point of *vena contracta*.

The coefficient of contraction is the ratio of the throat-ring diameter to the jet diameter at *vena contracta*.

The Crosby No. 1 pressure was taken at a point 1⅞ in. from the downstream end of the nozzle piece.

The Crosby No. 2 pressure was taken at a point 1⅞ in. from the upstream end of the nozzle piece, but was not used in calculating the effective head, due to difficulty in determining area of nozzle at this point, for different nozzles and needles.

The reading in ft. for Crosby No. 1 has been corrected for velocity, head and height of Crosby above the nozzle.

[3] Paper submitted by J. F. Davenport for subcommittee on current practice and research, hydraulic power committee.

EXPERIMENTAL NOZZLE TESTS—BIG CREEK NO. 1
BALANCED NEEDLE VALVE DESIGN—DIAMETER OF THROAT-RING. 0.860 INCHES

Test number	Static	32	33	34	35	36	37	38	39
Stroke in inches	0	0.188	0.163	0.138	0.107	0.081	0.056	0.031	0.016
Per cent wide-open stroke	0	100	87	73	57	43	30	16	9
Hg differential in inches	0	7.094	6.250	5.000	3.672	2.437	1.141	0.375	0.141
Relative flow in per cent	0	87.65	82.28	73.60	63.06	51.38	35.15	20.15	12.36
Per cent wide-open flow	0	100	94	84	72	59	40	23	14
Diameter of jet in inches	0	0.594	0.578	0.531	0.484	0.422	0.344	0.250	0.188
Coefficient of contraction	0	0.690	0.672	0.617	0.562	0.490	0.400	0.290	0.218
Relative diameter of jet—vena contracta	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Relative diameter of jet—Point (A)	0	1.136	1.103	1.094	1.125	1.116	1.229	1.320	2.263
Relative diameter of jet—Point (B)	0	1.254	1.172	1.207	1.167	1.209	1.343	1.640	2.632
Crosby No. 1	832	588.0	618.0	643.0	709.0	751.0	793.0	822.0	831.0
Crosby No. 2	822	580.0	612.0	639.0	706.0	749.0	793.0	822.0	831.0
Corrected Crosby No. 1—feet	1,920.3	1,378.8	1,445.8	1,500.2	1,649.0	1,742.6	1,836.0	1,901.0	1,921.1
Corrected relative jet velocity at 1,900 ft.	0	103.13	99.81	103.83	102.14	106.19	106.83	113.90	122.89

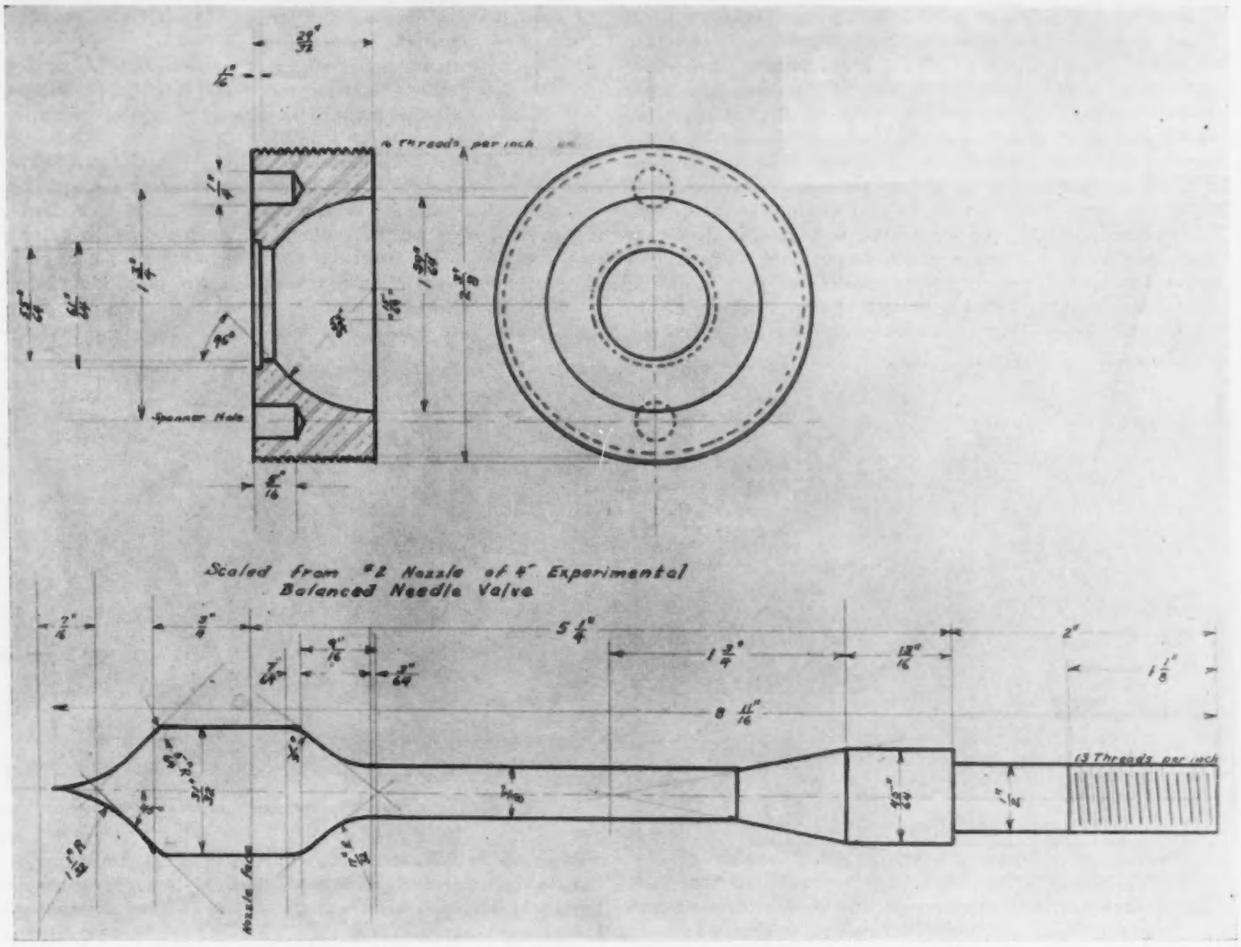

Fig. 2—A typical experimental needle and nozzle design

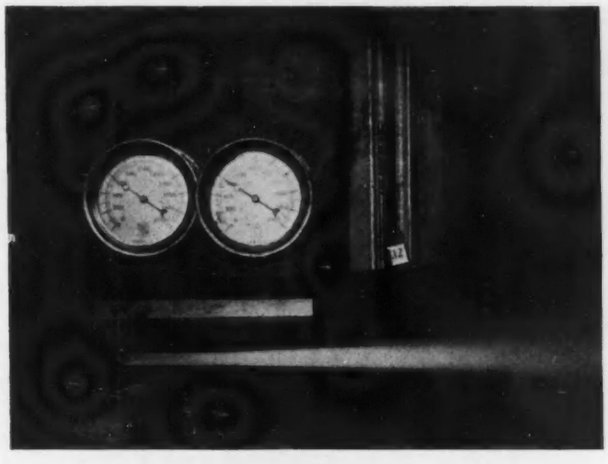

Fig. 3—Character of jet for test 32

The corrected relative jet velocity at 1,900-ft. head is an indication of the average jet velocity of discharge at 1,900-ft. head. The area of the jet at *vena contracta* was divided by the flow which gave the average velocity of discharge for the head at test. This velocity was corrected to 1,900-ft. head so that a comparison of discharge velocities could be made between designs.

All the jets were clear and free from spray for some distance from the orifice. However, all the jets showed a fine marking or grooving from the edge of the orifice to the *vena contracta*, although the inner contour of the nozzle and the edge of the orifice were perfectly smooth and polished. When very low pressures were used, this effect disappeared, as well as the spray which soon surrounds the jet at high velocities. Fig. 3 shows character of jet for test 32.

The parts were all made at the station and tests were conducted by G. R. Woodman, station chief, Big Creek No. 1, under supervision of D. H. Redinger, superintendent, Big Creek division.

Preliminary Report on Surge Suppressor Control in Pump Discharge Lines[4]

THIS preliminary report covers a novel means of limiting the pressure rise in a pump-discharge line, produced by the unstable flow immediately following power interruption to the prime mover of the pump.

The problems of unstable flow in power penstocks have been solved largely by suitable surge tanks and relief-valve systems operated in connection with the hydraulic power machinery. The problem with pump-discharge lines, however, requires special consideration, since the direction of flow reverses.

[4] Paper prepared by R. S. Quick for current practice and research subcommittee, hydraulic power committee.

With very small and unimportant pump-discharge lines, it has been customary to design the line sufficiently heavy to withstand the maximum possible water-hammer shock without damage. This usually has not involved any additional initial expense, since the ultimate strength of small-diameter pipe is ordinarily many times the working pressure normally experienced with pump-discharge lines. However, the increasing importance of the conservation and distribution of water for large irrigation works and metropolitan supplies, has resulted in pumping machinery and pipelines of such large size and initial investment that adequate surge-control means has been found, far more economical than a design of pressure equipment heavy enough to withstand the ordinary water-hammer disturbances accompanying power failure.

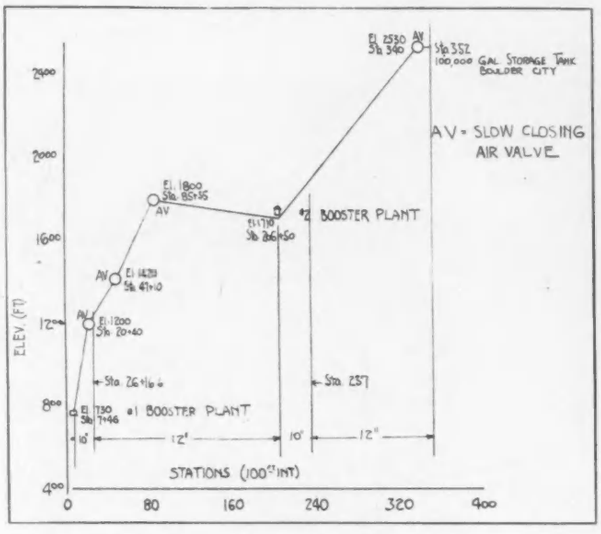

Fig. 1—Profile of static discharge head on Boulder City water supply line

The original experiments of Joukovsky disclosed that an air chamber of suitable proportions and method of connection to the pipeline, would reduce greatly the magnitude of a water-hammer disturbance. Consequently this device has been widely used. It involves, however, special air-compressor equipment and automatic means of maintaining the pressure fluid level under normal conditions and, where the pressure is

Fig. 2—Exterior booster plant No. 2

high, the initial expense for adequate protection is considerable. An alternate means of relieving the pressure rise has been to install spring-loaded relief valves on the pipeline. These valves in general have provided partial protection, but in many cases have proven entirely unsatisfactory on account of their delayed opening and tendency to initiate secondary surging of a periodic nature.

The firm with which the writer is connected has been interested in this problem for many years and lately has developed and installed a novel form of surge-control means which has been designated " a surge suppressor." It consists essentially of a needle-type valve arranged to open immediately following power interruption and before the excess surge appears. It takes advantage of the transient down surge immediately following power failure, using this sudden drop to actuate the opening means which may be responsive to change in pressure, or to an interconnection with the check valve actuated by electrical, hydraulic or mechanical means. This bypass connects to a lateral or tee on the discharge side of the

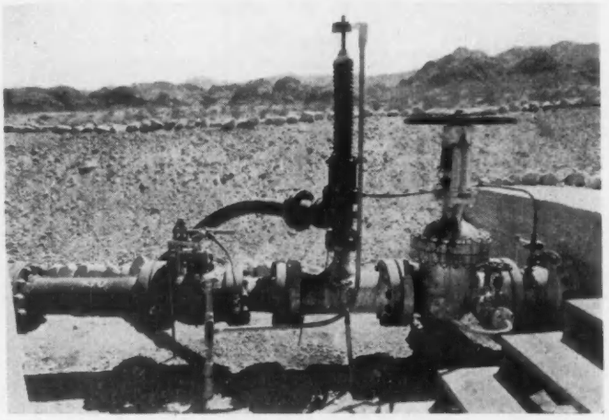

Fig. 3—No. 2 booster plant surge suppressor system

pump and, in fact, bears a striking physical resemblance to the standard form of relief valve employed with Francis turbines and impulse wheels, except as to the means and time of operation.

An interesting application of this control system is in the Boulder City water supply at Hoover Dam, which was placed in service in September, 1931. The No. 1 booster plant at the river contains three 200-hp. 3,450 r.p.m. four-stage, 4-in. pumps discharging into a manifold leading to a needle-type check valve and surge suppressor. The static discharge head on this line is approximately 1,040 ft. in a distance of 8,500 ft., the profile being shown in Fig. 1. The No. 2

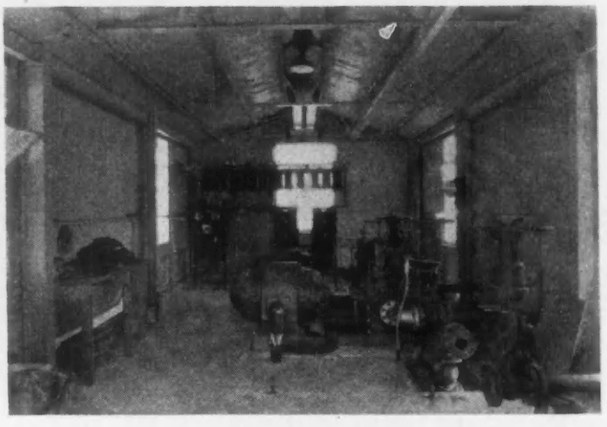

Fig. 4—Interior No. 2 booster plant

booster plant is a duplicate, except that the static discharge head is more nearly 820 ft. Each pump has a rating of 600 gal. per min. Figs. 2, 3 and 4 illustrate the No. 2 booster plant interior, exterior and surge-suppressor system. It will be noted that an hydraulic cylinder-operated gate-valve

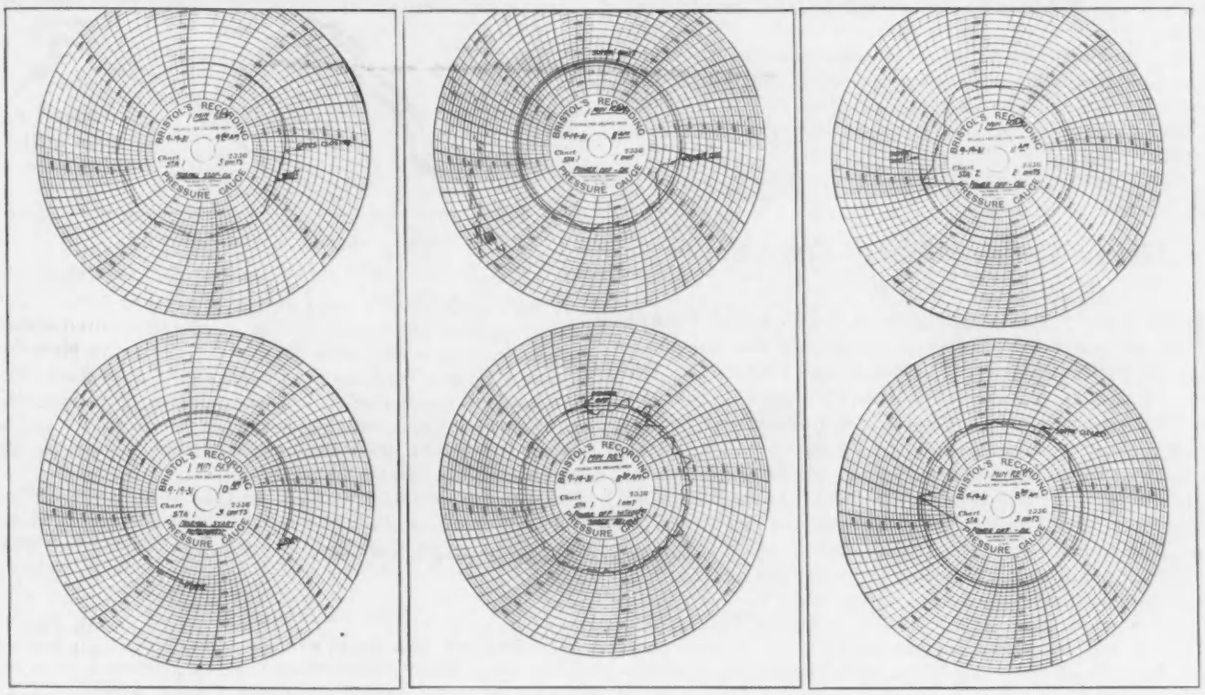

Fig. 5 (left)—Pressure-time curve when starting three units at station No. 1. Fig 6 (center)—Lower chart indicates pressure-time history in pump-discharge line following power interruption with only one unit in operation, with line check closure in about 5 sec., to be compared with upper chart obtained with surge suppressor adjusted to operate properly. Fig. 7 (right)—Corresponding pressure time charts for both booster plants

is located on the discharge of each pump, the control system being so arranged that pressure from the pump discharge is required to open the valve and pressure from the discharge line to close it, consequently making the operation absolutely foolproof and preventing accidental opening before the pump is properly primed. The switchboard panel is entirely automatic, the starting and stopping being controlled by float switches in the suction reservoir tanks at each station. When the starting signal is received, one or more pumps, as previously selected, start in sequence, each opening its own gate valve after pressure has been established in the pump and in response to a solenoid control, delivering water to the common discharge manifold. The needle line check between the manifold and pump-discharge line likewise is protected by having its opening pressure taken from the pump side, with solenoid timing control, opening only after the manifold pressure exceeds the static discharge-line pressure, thus insuring normal starting with a minimum of pressure disturbance. Fig. 5 illustrates the pressure-time curve when starting three units at station No. 1.

Should the water supply to the station be insufficient, the suction reservoir level drops and the float switch shuts down the plant. This switch acts upon the individual gate valves on the pump discharge, closing them while the units are yet running, stopping the respective motors by suitable limit switches actuated by the gate-valve tail-rods, thus gradually reducing the flow delivered to the pump-discharge line and producing shutdown, with practically a total absence of surge. A typical pressure-time chart is shown on the upper portion of Fig. 5.

It is obvious, however, that power interruptions will occur from time to time, and under these conditions a means must be available to protect the pumps from racing backwards and the discharge line from objectionable surge pressures. The bottom chart on Fig. 6 indicates the pressure-time history in the pump-discharge line following power interruption, with only one unit in operation, with line check closure in about five seconds. With two or three pumps in operation, the magnitude of the disturbance would be correspondingly increased and the maximum might easily exceed 700 lb., without the surge suppressor protection. Compare this with the corresponding chart obtained with the surge suppressor adjusted to operate properly as shown on the top of Fig. 6. Here the maximum pressure did not exceed 500 lb., or a rise of about 10 per cent above static head. Corresponding pressure-time charts are shown on Fig. 7 for both booster plants. At station No. 1 it will be noted that with a pumping pressure of 490 lb. the surge was less than 20 lb. above this value.

The purpose of the fast-closing line check is to prevent reverse flow or the racing of the pumps and motors backwards, the overspeed under pumping head being considerable and usually not provided for in standard motor manufacture. The reverse rotation also introduces possible electrical troubles with synchronous motor drives where direct-connected exciters are used and may also wash loose debris back into the pump impellers and do considerable damage. Where the discharge pipeline is short, so that check valve closure in five seconds or less does not create an objectionable rise in pressure, the surge suppressor is not required. However, when the pipeline length is such that retardation in rate of check valve closure sufficient to control water hammer results in objectionable reverse rotation, then full pipeline protection can be obtained only by the addition of a surge relief device in combination with a fast check.

Where high points exist in the discharge pipeline profile so that the water column may break during the reversal of flow, then a surge suppressor must be installed at such points, to act as a slow-closing air valve. This device opens when the gradient drops below the pipeline profile and again closes only very slowly after positive pressure reappears. The device then is a combination air inlet, air outlet, and slow-closing relief valve. The valves installed on the Boulder City No. 1 booster plant discharge line had a very marked effect on pressure-time history and it was possible to limit the surge at the pumping plant only by very slow closure of

the air valves which opened at the time of power interruption.

This problem will be of great importance in connection with projected pump-storage schemes for hydro-electric work and it is hoped that the principles now developed with smaller pumping plants will be of value in establishing proper operating conditions.

Siphon Spillway Tests—Tiger Creek Conduit[5]

THE Tiger Creek conduit is one of the important features of the new hydro-electric development of the Mokelumne River in California by the Pacific Gas and Electric Co. This conduit, with a capacity of 550 sec.-ft., extends from the Salt Springs dam to the Tiger Creek forebay and consists of 15.9 mi. of concrete bench flume, 2.7 mi. of tunnel, 1.5 mi. of elevated concrete flume, and 0.2 mi. of steel-pipe inverted siphon, making a total length of 20.3 mi. At several points along the conduit, feeder flumes are provided to pick up the flow of tributary streams. During certain seasons, run-off from heavy rain or melting snow increases the pick-up from these feeder flumes to such an extent that the main flume would be overtopped unless protected by automatic spillways. It was decided to use siphons for most of these spillways because of their reliability, close regulation of water-surface elevations, comparatively low cost, and freedom from maintenance care and expense.

[5] Paper prepared by T. J. Corwin and A. W. Kidder for subcommittee on current practice and research, hydraulic power committee.

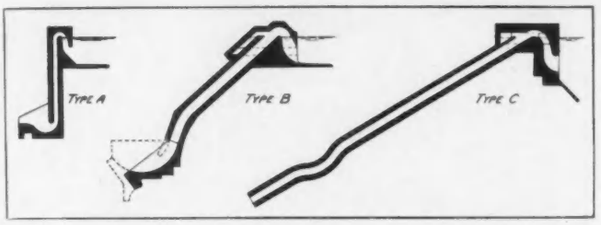

Fig. 1—Typical siphon sections

A brief description of each siphon is given in Table I and typical sections are shown in Fig. 1. Each of the inclined siphons was provided with an auxiliary priming weir as well as a vertical bend near the lower end of the barrel. The vertical bend was included, to assist priming by causing the thin sheet of water running down the barrel to jet to the top of the barrel, thus forming a curtain preventing the entrance of air from below.

This article will describe tests on four of the seven siphon spillways, made to check the rise in water-surface elevation required to prime them and to prove the adequacy of their capacity.

Test of Siphon No. 3

The first test was made on siphon No. 3 which is located on the Bear River feeder flume 100 ft. upstream from its junction with the main Tiger Creek flume. A radial check-gate located 100 ft. downstream from this junction made an ideal set-up for this test.

Four piezometer connections, located as shown in Fig. 2, were built into the barrel to be tested. Mercury-filled U-

SIPHON SPILLWAYS ON THE TIGER CREEK CONDUIT—TABLE I.

Spillway No.	Designed Capacity sec. ft.	Head ft.	Barrels No.	Barrels Size ft.	Barrels Inclination	Sealing Pool	Type (See Fig. 1)	Location
2	310	25	2	1.0 x 6.5	Vertical	Yes	A	Cold Creek Feeder
3	575	23	2	2.0 x 6.25	41° 30′	After test	B	Bear River Feeder
4	100	19	1	1.0 x 3.25	Vertical	Yes	A	East Panther Cr. Feeder
			1	0.75 x 2.25				
5	100	7	2	1.0 x 3.25	Vertical	Yes	A	West Panther Cr. Feeder
				0.75 x 2.25				
6	200	10	2	1.0 x 6.5	Vertical	Yes	A	Deer Creek
7	640	23	2	2.0 x 7.0	41° 30′	After test	B	China Gulch
9	660	35	1	1.5 x 1.5	30° 20′	No	C	Tiger Creek Forebay
			1	1.5 x 3.0				
			2	1.5 x 5.5				

TEST OF SIPHON SPILLWAY NO. 3 AT BEAR RIVER—TABLE II
TIGER CREEK CONDUIT

Run No.	Date	Time	W. S. Elev. Above Crest	Stage	Vacuum at Piezometers No. 1	2	3	4	Remarks
(1)	(2)	(3) h.m.s.	(4) ft.	(5)	(6) ft.H_2O	(7) ft.H_2O	(8)) ft.H_2O	(9) ft.H_2O	(10)
1	9-15-31 a.m.	10:52	0.26		0.11	0.00	0.11	0.11	2x8-in. plank across bottom of barrel 8 ft. below crest.
		10:55	0.33		0.23	0.00	0.17	0.17	
		11:00	0.44		0.23	0.06	0.23	0.23	
		11:02	0.46						
		11:04	0.52	Failed	0.34	0.11	0.28	0.34	
		11:10	0.60	to prime					
2	9-16-31 p.m.	12:08	0.06		0.00	0.00	0.00	0.00	2x8-in. 8 ft. below crest. Wooden extension of wall between the two siphon barrels. 3-in. pipe air-ejector down center of barrel.
		12:09	0.41		0.11	0.11		0.34	
		12:10			0.51			0.57	
					0.57				
		12:11	0.60		0.68			0.68	
		12:14	0.59	Failed	0.57				
		12:17	0.65	to prime	1.02			1.02	
7	9-17-31 a.m.	9:29	0.00						2x8-in. plank 8 ft. below crest. Extended wall. Current meter measurement. Q= 329 sec.-ft. Average W. S. at crest elevation. Vortex allowed air to be drawn into siphon intake. Slight vibration noticeable. 2x8-in. torn out by discharge.
		9:30	0.32						
		9:30:30	0.47						
		9:31	0.57						
		9:31:15		Primed					
		9:31:30	0.46		7.9	25.0	16.4	14.2	
		9:32	—0.04						
		9:39	0.10		9.1	23.8	18.1	19.3	
		9:43		Vac. broke	0.0	0.0	0.0	0.0	

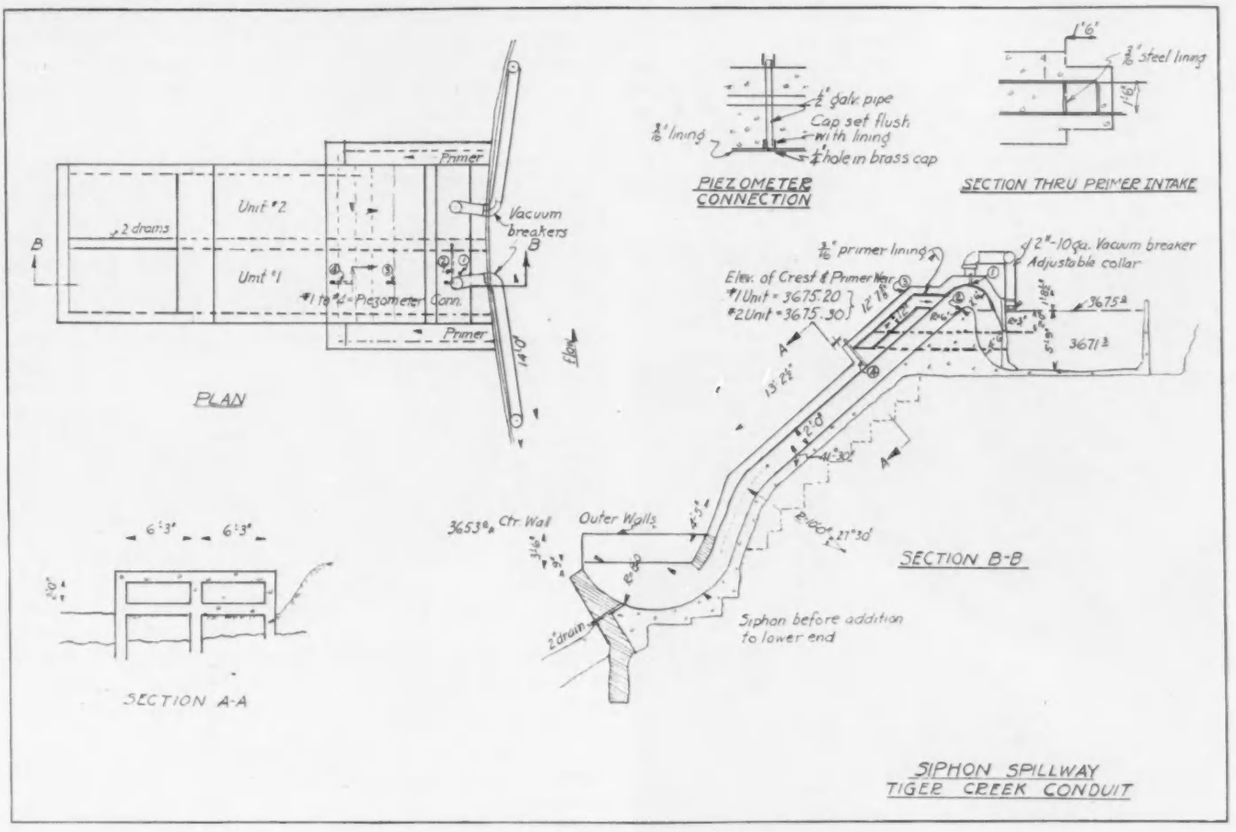

Fig. 2—Piezometer connections

tubes, with the necessary interconnecting hose and shut-off valves, were connected to these piezometers. Before starting the test, one barrel of the siphon was closed with boards to conserve water and also to reduce the discharge to a quantity which could be supplied by the main conduit while a current-meter measurement was made. The flow in the main conduit during the test was 450 sec.-ft. In making each run, the check gate was partially closed, so as to back the water up in the feeder flume until the siphon either primed or else the water surface was as high as the available freeboard permitted. In run No. 7, after the siphon had primed, the gate was still further adjusted to maintain as nearly as possible a constant water level during the current-meter measurement. The water-surface elevation adjacent to the siphon was obtained by use of a portable stilling-well gage.

The results of tests on siphon No. 3 are summarized in Table II. The first attempts to operate this siphon were unsuccessful and so various modifications were devised and tried out before an entirely satisfactory means of causing priming was found. In a preliminary series of tests, several types of sills or baffles fastened across the floor of the siphon-barrel were tried in various locations. None of these proved capable of starting the siphonic action, with the depth of overpour limited to 7 in. by the available freeboard.

Fig. 3—Siphon No. 3 outlet as originally constructed, discharging about 20 sec.-ft. without priming

During these preliminary tests it was noted that the vertical bend near the lower end of the barrel was not wholly effective. (See Fig. 3.) The wall between the two barrels stopped abruptly, leaving an entrance for air to the under side of the sheet of water, which was deflected to the roof of the barrel by the bend. There was then only one sheet of water through which the air had to break in order to prevent the formation of a vacuum higher up in the barrel.

Run No. 1, Table II, was a repetition of one of the preliminary tests but with vacuum gages attached. In order to make use of the additional vacuum-producing "curtain" of water falling from the roof at the lower end of the barrel, a wooden extension of the wall between the two barrels was built. At this time a 3-in. pipe was also fastened to the floor of the barrel, extending from the throat to the vertical bend. This was intended to act as an air ejector. Run No. 2 was made with this arrangement. The gages showed considerably greater vacuums but still the siphon failed to prime. This failure was ascribed to the break in the sheet of water, due to the obstruction offered by the ejector pipe, through which air could enter. This break was noticeable at the outlet.

Several runs were made with various alterations, which showed that the siphon would prime when the pipe was removed, but a 2x8-in. plank across the floor of the barrel, 8 ft. below the crest, was necessary. Table II, run No. 7, gives

data on the siphon under these conditions. Fig. 4 shows the solid water at the outlet during this run.

The 7-in. rise in water surface to start the siphon, as found necessary in run No. 7, was considered excessive, so additional alterations were undertaken. The roof of the lower end of the barrel was extended and a sealing pool was constructed, as shown in Fig. 2. Temporarily these additions were made of wood. The siphon, altered in this

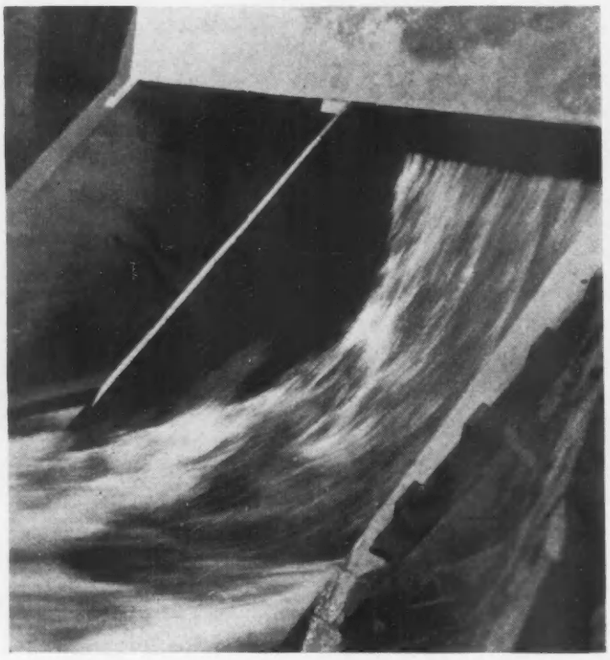

Fig. 4—Siphon No. 3 with temporary center-wall extension. One barrel discharging 329 sec.-ft.

way, primed with a depth of only 0.31 ft. over the crest. The priming took place with 0.26 ft. over the crest when the 2x8-in. plank was in place, but it is thought that this decreased depth was due to a slower rise in the water surface, rather than to the presence of the plank. With the priming waterway closed by boards and the 2x8-in. removed, the depth to start the siphon was 0.41 ft. The discharge for a depth of 0.41 ft. over a weir is just twice that for a depth of 0.26 ft. In other words, for a depth of 0.26 ft. the discharge over the crest of the siphon, plus that over the primary weir, is the same as the discharge for a depth of 0.41 ft. over the crest alone. Therefore, it appears that the only function of the priming weir in this siphon is an increased flow and therefore lower depth required for starting the siphon. This indication that the flow over the priming weir failed to seal the barrel and to assist in rarefying the air in the throat is confirmed by the vacuum readings, which were practically the same on both sides of the priming weir.

The coefficient of discharge (C) was 0.69, based on the flow measured during run No. 7 and computed by the following formula:

$Q = CA\sqrt{2gh}$.
Where $Q = 329$ sec.ft.
$A = 12.5$ sq.ft. = area at throat.
$h = 22.6$ ft. = head between intake water surface and center of outlet.

The coefficient of discharge as above computed does not take into account the fact that some water was flowing through the breaker pipe and the priming waterway. This flow, of course, reduced the quantity through the main intake and throat and theoretically, at least, reduced the friction and entrance losses, thereby increasing the coefficient of the siphon. However, it can be assumed that the amount of water thus bypassed was comparatively small, due to the sharp entrance and right-angle bends in the priming waterway, and that the coefficient is therefore only slightly affected.

Tests of Siphons No. 4 and No. 7

Siphon No. 4, type (A) in Fig. 1, was tried by an operating crew and found to function satisfactorily.

Siphon No. 7, type (B), Fig. 1, and identical to No. 3, was extended and provided with a sealing pool, exactly as had been found desirable by the tests on No. 3. It was then tried and found to prime with a depth of only 1¼ in. over the crest. Fig. 6 shows this siphon with full discharge from one barrel. The rate of rise of the water surfaces in this trial was very slow, giving considerable time for rarefying the air in the barrel. There seems to be no reason why siphon No. 3 would not also prime with this slight overflow, if the water were raised slowly.

Test of Siphon No. 9

Siphon No. 9 at the forebay is of type (C), Fig. 1, with the addition of a vented concrete transition at the lower end, connecting to a steel waste pipe. Fig. 7 shows discharge from this pipe. There was, therefore, no way of forming a water seal at the lower end of the barrel. The depressed section or double vertical bend was relied upon to furnish the seal and rarefy the air.

Connections for the vacuum gages for the tests of this spillway were made by tapping into the vent or siphon breaker pipes.

Tests of this siphon consisted of two runs. The first run was made in one barrel only, to determine the depth of overpour required to cause priming. For this run, two of the four barrels were closed off by board shutters across the intake. The crest of the fourth barrel was at a slightly higher elevation and therefore did not need to be closed off to prevent priming. The water surface was raised at the rate of 0.04 ft. per min. and priming occurred at a depth of 0.28 ft. over the crest.

The object of the second run was to determine the maxi-

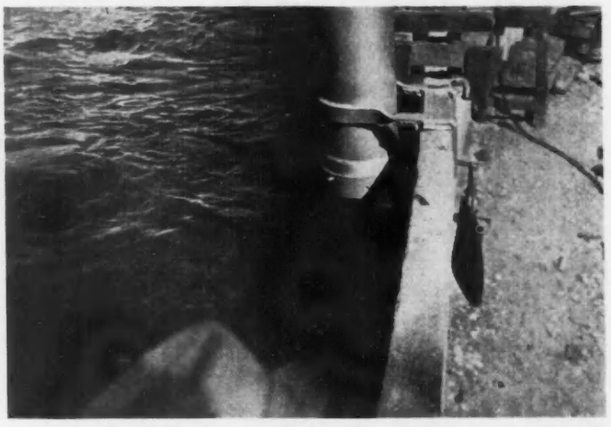

Fig. 5—Water being drawn up into breaker pipe before siphonic action was stopped

mum rise in water surface which might be expected during normal operation of the spillway. It was made with all the barrels open and with a water surface rising at the rate of 0.14 ft. per min. The crests of the four barrels composing this spillway are set at three different levels. The smallest barrel is set to prime first. The crest of the next

larger barrel is 0.1 ft. higher and the crests of the two largest barrels are 0.2 ft. higher than the crest of the smallest. In this run the maximum depth over the crest of the smallest barrel was 0.42 or 0.22 ft. over the crests of the two largest barrels. The four barrels primed in rapid succession, with less than a minute elapsing between the priming of the first and last.

Fig. 6—Outlet of siphon No. 7. Discharge about 360-sec.-ft. through one barrel

The U-tubes at the time of priming, indicated a vacuum equivalent to 0.5 ft. of water, which is less than half of the vacuum required to prime siphon No. 3. The actual vacuum at the throat is unknown, as no piezometers were built into this siphon. No measurement of discharge was obtained but the rate of draw-down in the forebay indicated a flow approximating the designed discharge.

Conclusions

These tests indicate the necessity of sealing the lower end of inclined siphon barrels, either by a sealing pool, which is probably most effective, or by vertical bends, causing the sheet of priming water to jet across the barrel several times. The latter method is less positive than the sealing pool.

Where a siphon is required to work on a very small rise in the intake water surface, as in cases where the freeboard is very limited, the auxiliary priming weir seems to be justified, since in these tests it reduced the depth at which priming occurred by nearly 2 in.

The advantage of a low throat section, in regard to the vacuum required for priming, is shown by the tests of siphons No. 3 and No. 9. Siphon No. 9, with a throat 1.5 ft. high, primed with a vacuum equivalent to 0.5 ft. of water, while Siphon No. 3, with a throat 2.0 ft. high, required a vacuum of over 1.25 ft.

Fig. 7—Waste pipe from siphon No. 9 discharging approximately 660 sec.-ft.

With enlarged inlets, submerged as in the siphons tested, there is very little disturbance in the water surface adjacent to the inlet. Therefore, the vacuum breaker pipes could as well be placed directly in front of the inlets, instead of to the side, as shown on Fig. 2. A small vortex, allowing the entrance of air, formed during only one run of siphon No. 3. This air did not affect the vacuum readings, which were about the same for all runs. According to these tests, the ends of down-turned vacuum breaker pipes with an area of six per cent of the throat area, should be about 2 in. above the water surface elevation at which it is desired to stop the siphon. See Fig. 6 for siphon steel operating with water surface below breaker pipe and a solid column of water being drawn into pipe.

The discharge through these siphons started and stopped very smoothly and the operation was without serious vibration at any time. The addition of the sealing pool did not cause pulsations, as has been described at other siphons, and apparently had no effect upon the discharge.

In making these tests, the main objects were to make sure that the siphons would prime with the freeboard which was available and to prove that their capacity was sufficient. When the siphon did not prime, the tests were continued to indicate what alterations should be made. The collection of scientific data was incidental. In making tests for this latter purpose, the following points should be observed: First, more piezometer connections should be installed. Second, oscillations of the mercury column should be damped. Third, the rate of rise of the water surface should be controlled.

These tests were made by the authors with the cooperation of F. C. Scobey, senior irrigation engineer, U.S. Department of Agriculture, and G. M. Wehrle, superintendent of construction.

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*Economic Phase of Existing Hydroelectric Plants**

The report on economic phases of existing hydro-electric plants has as its purpose the providing of practical suggestions for simplification and modernization of plants now operating for member companies.

THE close connection between the generator and the waterwheel prompted the inclusion of this part of the hydraulic plant along with the consideration of hydraulic data. Representatives from the major electric manufacturing companies were therefore included in the personnel of the committee.

The trend of the times, together with the practically complete lack of any major hydraulic development in the geographical section covered by the Pacific Coast Electric Assn., gives time for thought and action toward increasing the return from already existing installations. A consideration of this subject will also include ways and means of decreasing operating costs.

Each of the companies has on its system a number of plants which have been operating for a long time and which are showing less and less output each year.

There is, of course, a difference between waterwheels and the average efficiency at which they are being operated. In order to compare the output of one machine with another, it will be essential to have the correct, or at least the comparative, input, taking into consideration all water-passage losses.

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* Report of subcommittee on economic phase of existing hydro-electric plants, hydraulic power committee, Engineering Section. C. B. Carlson, chairman. R. J. Cobban, T. J. Corwin, S. F. Coghlan, C. L. Davis, H. K. Fox, H. E. Fuqua, H. V. Lutge, W. H. Holcomb, E. F. Marvatt, D. H. Redinger, E. M. Scott, H. C. Stanley, E. A. Quinn, H. S. Warren, W. J. Young.

Machine loading should be watched, as different machines have different efficiency characteristics. Also, where there are a number of machines in a plant, the amount of load for each machine and the number of machines which are run should be studied for any given load. It will be found that additional output will be obtained by watching these features closely.

Some system of forecasting rising water conditions as far ahead as possible, so as to take full advantage of stream flow, in the case of that kind of plant, and of maintaining storage capacity for reservoir plants, will result in the best use of all available water.

The plotting of forebay levels as a function of generated output will indicate whether water passages are obstructed or whether units are working up to capacity. The investigation of the use of waterwheels as condensers on the system will often show added usefulness of the plant to the system. If a plant is kept fully ready for immediate service, it may develop that the amount of water used in condenser operation will not vary greatly.

Frequent and careful inspection of the machines in a plant will pay for itself in the continuity of output. Because a plant is old and small, should be no excuse for neglecting its maintenance in good running order. The aggregate sum of the output of a number of small plants can have a considerable effect on the operation costs of a system which has to depend on filling in the deficiencies with power made with purchased fuel.

Advantage should be taken of the results of research, which is providing materials for wearing parts which will give much longer life. This reduces shutdowns and consequent loss of revenue, as well as putting an end to the decreasing efficiency in output.

The amount of spare parts which should be stocked at a plant for emergency repair is a matter which should receive serious consideration. Much capital has been tied up in such items, the carrying charges being a part of the operating expense. An exchange of experiences between the member companies would be the means of bringing about the possibility of avoiding needless expense.

The location of the plant with respect to its access from some base of supply should influence the amount of money invested to care for emergency or routine work.

The providing of living conditions at a plant, such as to make for contentment of the personnel, is a vital consideration in keeping up interest without letdown.

Many of the smaller plants are isolated from the regularly traveled sections and, because of their lesser importance in comparison with the newer and larger developments, are often more or less neglected. It has been truly said that when considering the inspection and maintenance of machines, we should consider also the same items as applying to men, avoiding thereby accidents to men and machines through lowered morale or physical deficiencies.

In any industry where rapid progress is being made in the design and improvement of equipment, the problem of modernizing and simplifying existing plants to permit taking advantage of the economies offered by improved performance, is an important one. This is particularly true in the hydroelectric field, where in the past ten years both the mechanical and hydraulic features of design have been improved tremendously.

Consideration of this problem with respect to hydraulic prime movers should be divided into two major classifications, the first including those plants requiring the replacing of obsolete equipment with entirely new machines, and the second, plants which can be reconstructed to provide operating characteristics which are the equivalent, or nearly the equivalent, of those obtained from new units.

Obviously, the plants coming under the first classification are those in which the physical limitations of the original design are such that it would be impossible, either from the standpoint of cost or due to the arrangement and construction of the original machine, to redesign and reconstruct them to provide operating results which would be comparable to those obtained from a unit of modern design, and which would warrant the expenditure involved in such reconstruction.

In such cases it has frequently been found feasible from an economic standpoint to abandon the original machinery, and to replace it with entirely new equipment, with which, of course, the advantages of modern design can be secured.

On the other hand, there are in operation a great many plants, the original design of which is such that they lend themselves readily to comparatively economical reconstruction, with results which not only greatly reduce the operating attendance required, but appreciably increase the output obtained from the units with a given water quantity under a given head condition.

While this statement is true of both reaction turbines and impulse wheels, it applies particularly to the latter, as recent progress in nozzle and bucket design, as well as in bucket ratios has been rapid.

As an illustration of this point, a description of a rebuild of an actual unit might be given. This particular unit is a horizontal impulse machine, having two runners mounted on a single shaft and in a single housing. Each runner was served by an independent open-stream nozzle of the deflecting type, actuated by an oil pressure governor. The unit was originally designed to develop 3,000 hp., under 1,150 ft., at a speed of 300 r.p.m. The unit had been in operation for a period of about 25 years, during which time it had been provided with normal repairs, but no changes in design had been made. Recently, it was decided to undertake the reconstruction of this equipment to obtain improved operating characteristics and to modernize the entire installation.

To accomplish this result, a careful study was made, with the following results: The two original runners were replaced by a single runner having an extended hub to equalize the forces and permit using the existing shaft and bearings, which were in excellent condition. A special nozzle of the bifurcated type was developed to bring together the two connections formerly used for the two runners and to provide a single jet. This nozzle was of the hand-controlled needle type provided with a stream deflector, arranged for connection to the existing oil pressure governor and to provide speed regulation.

In order to secure satisfactory control of the water within the housing, special baffles were provided on either side of the runner, and were welded to the existing housing. These baffles on the lower end were supported by suitable struts.

The result of this reconstruction provided a thoroughly up-to-date simplified unit, at an extremely reasonable cost, which was obviously very much worth while.

In the example given above, the unit was of an entirely obsolete design and consequently the reconstruction necessary to bring it up to date involved the replacing of all of the major parts. There are many units now in operation whose operating characteristics can be greatly improved with even fewer changes. In many cases, existing deflecting nozzles, which are the source of considerable difficulty due to their involved construction and many parts subject to rapid wear, can be easily replaced by modern straight-flow needle nozzles provided with governor-operated jet deflectors, which will not only give improved operating characteristics but will greatly simplify the construction, and consequently reduce the maintenance costs which are a very definite part of the cost of operation.

With the recent advances in bucket design and construction, the efficiency of many existing plants can be materially increased by simply rebucketing existing runners, or by installing complete new runners. In some cases it is advantageous to replace existing oil pressure governors with hydraulic controllers, where the unit is part of a large system

and the governing is done from one plant. This, of course, greatly reduces the cost of maintenance, and the hydraulic controller provides the necessary safeguards to protect the unit.

In other cases, by equipping existing units with relief valves of modern design, the problem of pressure control in the penstock can be satisfactorily solved and in many cases the necessity of replacing either all, or a portion, of the penstock eliminated.

There are a number of cases on record where the efficiency of reaction turbines has been very considerably increased by the installation of new runners, guide vanes, and their related parts.

Another important point with both impulse wheels and reaction turbines which must be given consideration in any discussion of this nature, is the economy which may be effected by so altering the design of existing equipment as to permit either automatic or remote control.

A very considerable amount of study has been given to this matter in the past few years and it is now considered thoroughly practical not only to design new plants for either automatic or remote control, but in many cases to convert existing plants for that purpose. The resulting saving in operating costs is great, and often the continued operation of an existing unit can be justified economically by converting it, either for automatic or remote control.

The following means of simplifying and modernizing indicate what can be done along these lines. Economies of existing plants may often be improved by:

Partial reconstruction of units and by installation of improved parts.
The use of new materials and methods.
Simplification of operation, with a reduced labor charge.
Improved operating conditions by the careful study of the units, including their efficiencies and the use of water.

In one of the Big Creek plants of the Southern California Edison Co. Ltd. a great deal of modernization has been carried out during the past three years, with resulting economies, but upon which it is difficult to put the dollar sign. In this one plant the three main turbines have been rebuilt, using parts of improved design. This has resulted in an increase in the station capacity from 86,000 kw. to 98,000 kw., together with an increase in efficiency of about three per cent over their entire range. Liberal initial design of the generators and transformers has enabled this overload to be carried continuously without trouble. Some of this work has been in the interest of reliability of service which is of prime importance.

Under this head would come such items as the following:

Installation of quick-response excitation.
Adequate fire protection of governors.
Generous transmission capacity.
Improved relay protection.
Adapting governors for 50 to 60-cycle operation.
Carrier-current telephones over the transmission lines.

A careful study of all operating conditions, the establishing of proper efficiency curves and tables, the making of regular two-hour efficiency checks, plant operation at the most favorable load factors, and the maintenance of maximum heads at the forebays have resulted in a large increase in the respective station output brought about by the improved use of available water.

The Big Creek division operators of the Southern California Edison Co. Ltd. are provided with efficiency curves of all Big Creek units and from these, tables and supplementary curves have been made, by which the best loadings for plants, for individual units, or combinations of units can be determined. The results of the current loading are determined every two hours by a check being made, and if any question arises as to the relative merits of different combinations of units, or some efficiency appears wrong, a special check is requested and made.

Tables and curves of meter correction factors, tunnel and penstock losses, tailrace elevations, etc., for various loads and flows, are furnished each plant.

Venturi meter tests are made regularly. Results of each test are telephoned to the division operator on shift, who plots them on a form which provides for curves of forebay elevation, kw.-hr. per acre-ft., and division load. At the end of each day, kw.-hr. generated average load, acre-ft. used, kw.-hr. per acre-ft. average head, and kw.-hr. per acre-ft. head are computed for the day.

An effort is made to keep each machine and each plant loaded at the best point. If system capacity requirements permit, a unit may be shut down until a better load is available. An impulse unit will be put on the line and motored for capacity to permit shutting down a reaction unit, if by so doing there will result a saving. Forebay elevations are kept as high as conditions will permit, in order to maintain a maximum head on the respective plant.

Based on the water used in 1931, the increased efficiency in 1931 over 1930, resulted in an increase of approximately 19,840,000 kw.-hr. in output for the Big Creek division. This was due to better loading, increased efficiency of units and the fact that wide-open loads were carried for a shorter period in 1931.

During run-off periods, when water is being spilled, the use of larger throat-rings on impulse units, or maximum gate openings on reaction turbines to increase output, is an economy, if such procedure will reduce fuel consumption at the steam plant or afford better loading for machines using storage water, even though the machines with increased output operate at a lower efficiency.

A central oil system with closed waterproof sumps and additional pressure-tank capacity was installed to eliminate excessive pressure drop at governors previously experienced during heavy operating demands. Main and standby motor-driven oil pumps were added with a waterwheel-driven pump for emergency service.

Venturi-tube-controlled automatic headgate closing equipment was installed to close automatically penstock headgates in case of abnormal flow, indicating penstock failure. No actual operations, under failure, have occurred since installation.

Lubrication is by Alemite push-type compressors for general greasing and button head fitting with H-15 service compressor for large hydraulic gland greasings to replace grease cups and hydraulic rams. A material saving in grease and time is effected.

The cost of lubricating machinery has been more than cut in half by the use of correct Western products, by the reclamation of oil by means of a centrifugal oil purifier and by the use of the smallest possible number of different products. Some of our experience has been that the Western products give equal satisfaction, when compared with Eastern products, at a much lower cost.

Governor and bearing oils have been centrifuged and filtered through blotters at regular intervals, while partly emulsified oils have been reclaimed.

Tests for acidity have indicated oil is still in good condition and that a complete change will not be necessary for some time.

Switch and transformer oils have been standardized, with resulting economies and with the necessity of smaller stocks. A universal oil, suitable for the switches and transformers, is now in use at certain plants.

The replacing of two hand-operated plunger-type valves with new hydraulic disk valves on one unit has been very satisfactory. The follower ring-type valve offers no obstruction and gives no swirling to stream flow. Considerable

trash, old ties, and debris from a tunnel had been caught in the plunger valves.

Remote-controlled load-blocking devices have been installed on certain governors, to allow the switchboard operators to set loads on machines. This relieves floormen of unnecessary work.

The exciters for three units in one plant are waterwheel-driven, with a belt-driven governor for each exciter. In order to prevent the exciter running away in case of belt breakage, automatic load-blocking devices have been installed to block the load on the exciters at the load being carried when the belt breaks.

Solenoid ratchet drives on two old exciter rheostats have been replaced with motor drives, which have proved reliable and satisfactory, especially during trouble conditions, where they are absolutely necessary for positive drives.

Late design buckets with strippers and baffles have been installed on some units with resulting increase in hydraulic efficiency of the units. The new design buckets, however, are much thinner at the entering edge and cause considerable trouble and maintenance expense by frequent breakage, which did not occur with the old designs. It is expected that the life of the new buckets will be much shorter than that of the older designs.

The use of stainless steel and nitralloy in valves, pressure-reducers, and control valves operating with water, has proved an economy in maintenance.

Use of stellite for power nozzle-needles and throat-rings proved economical, by reason of its long life as compared to brass, but was expensive, due to machining and grinding costs and was also troublesome because it would flake off easily if it was applied or ground too thin at the seat. Nitralloy seems to be more successful and economical for this service, as it costs less for machining and does not flake off. No information is available yet at this plant on comparative life of nitrolloy as compared with stellite.

Stainless steel has been used to good advantage for valve stems and other parts subject to corrosion.

The seal rings of vertical machines have been run to closer fits by the use of soft-metal (Parsons white brass) inserts in the steel ring. This not only provides a way to prevent damage to the runner should it touch the seals, but its use permits, with economy, the more frequent changing of the seals.

Closer initial fits for the seal rings also result from grinding the liner plates to size after installation, rather than depending on the factory fit, as in this way any small errors in assembly may be corrected.

The use of standard colors for painting the interior and exterior of all structures has reduced painting costs. Application with air brushes is satisfactory and economical. The results from the use of aluminum paint have been gratifying.

Chromium plating has been found satisfactory and ecomical for certain parts, such as instrument dials. A very good appearance is presented, as well as freedom from corrosion.

A special glass called "no glare" has been used to good advantage on the electrical meters in the division operator's office. Formerly the instruments were hard to read at night. The new glass has corrected this.

The substitution of telechron clock-drives for recording instruments has been very satisfactory and economical. Conventional clockwork-drives have given a great deal of trouble and are difficult to regulate to the limits required.

Experiments are being made with colloidal paints of the asphaltic-emulsion type. It is expected that this type of protection will be satisfactory for metal work subject to continual moisture.

Frequency meters in conjunction with master clocks have been used to control the system speed-time. Very good results have been obtained, both as to error in time and the maintaining of a close average frequency.

Recorders have been installed to assist in the study of line conditions during the time of system disturbance. Much valuable information has been gained.

Theostatic-type voltage regulators have been very satisfactory. Their maintenance cost is far less than the vibrating type.

Neon glow lamps have been used economically for certain pilot light installations to good advantage. The new type 18-volt resistance-base pilot-lights have been employed economically in places where the burnout by vibration of the standard type was too high. The cost of this type of pilot-light is less and the replacement is less frequent.

The use of open steel grating to replace wooden floors in valve rooms has given better ventilation, illumination and inspection.

A frequency controller for maintaining average frequency correct for telechron time has been installed.

Secondary and control wiring has been improved by the use of lead-covered cables in place of rubber-covered wire in conduit. The cables are laid on racks and are therefore much easier of maintenance, changes to control circuits are more easily made, and the initial cost less.

Carrier-current telephone communication has been greatly improved during the past year. On one occasion last summer, the carrier-current telephone was used, during a three-phase short caused by a gas fire, to transmit an order for switching, which switching eliminated the trouble. Communication over the regular telephone lines at this time was impossible.

Frequency and time regulation are becoming of increasing importance. Many synchronous clocks are being put into service, and they must be kept accurate within small limits. Frequency regulation is more of a problem. If instantaneous frequency is held within close limits, time errors accumulate slowly, and can easily be corrected. Heavy and rapid speed swings are most difficult to control, and cause more trouble for consumers. Some processes depend greatly upon uniform speed, and are more hampered by "hunting" and rapid fluctuations than by slower, sustained deviations from normal frequency. An example of this is the production of sound motion pictures.

Automatic frequency controllers have been installed in two of the plants. These are of some value during off-peak periods, when load remains practically constant for a considerable time and swings are light. At other times, they must be assisted by manual control. Peak loads come on and drop off at a rate beyond the capacity of governors and controller. It is, therefore, necessary to make manual adjustments of governor settings. Otherwise, as load accumulates, speed will continue to drop and as load decreases, speed will continue to rise.

If the controller is adjusted for large changes in load, a condition of "hunting" is set up, with objectionable large and rapid speed swings. Modernization or replacement of governors will accomplish as much along this line as the addition of supplementary devices which are not equipped with compensation and are not designed to fit governor or system characteristics.

Other items which might be suggested in considering the simplification and modernization of plants are:

Installation of new improved design governors for securing better speed regulation, these governors to be equipped with needle position and load-block position indicating selsyns at the switchboard to aid the operator in efficient handling of the machines. The governors to be automatic, starting by the closing of a switch interlocked with a mercoid pressure switch on bearing oil lines, so that under emergency operations the units will be up to speed and ready for synchronizing by the time the operator has his transformer switching done.

The governors are to be equipped with automatic speed-

matching motors to save time during system disturbances, which is a step toward automatic synchronizing with manual supervision.

Remote-controlled electrically operated oil valves may be provided for the generator bearings, so that the switchboard operator can apply pressure oil to the bearings and start the machine from the switchboard.

Remote-controlled electrically operated devices may be installed on each exciter governor to start automatically and to put them on governor control in fifteen seconds by closing one switch on the switchboard.

Installation of automatic loading equipment for efficient loading of the individual units will secure maximum plant efficiency for any load while regulating system frequency.

During the last few years modern methods and materials have greatly changed maintenance methods. Better work and lower costs have resulted.

Electric welding has been employed to repair parts that would formerly have been discarded. In particular, repairs to turbine wicket gates have been made and the original fits have been restored, eroded spots on turbine runners have been repaired, making the repaired runner equal to new. Buckets on impulse wheels are also being repaired by the use of the electric arc.

Carboloy tool bits have been used to improve the accuracy of machining, as well as to increase the speed at which the work can be done.

Results obtained from some actual modernizing jobs are reported as follows:

The Poole plant of The Southern Sierras Power Co. was changed in 1931 to manually supervised automatic control. An operator is not in attendance, but is called by alarm. The unit removes itself from the line. Much operating expense is saved by this installation.

Bishop Creek plant No. 3 was provided with differential protection. This was done to prevent greater maintenance if windings break down.

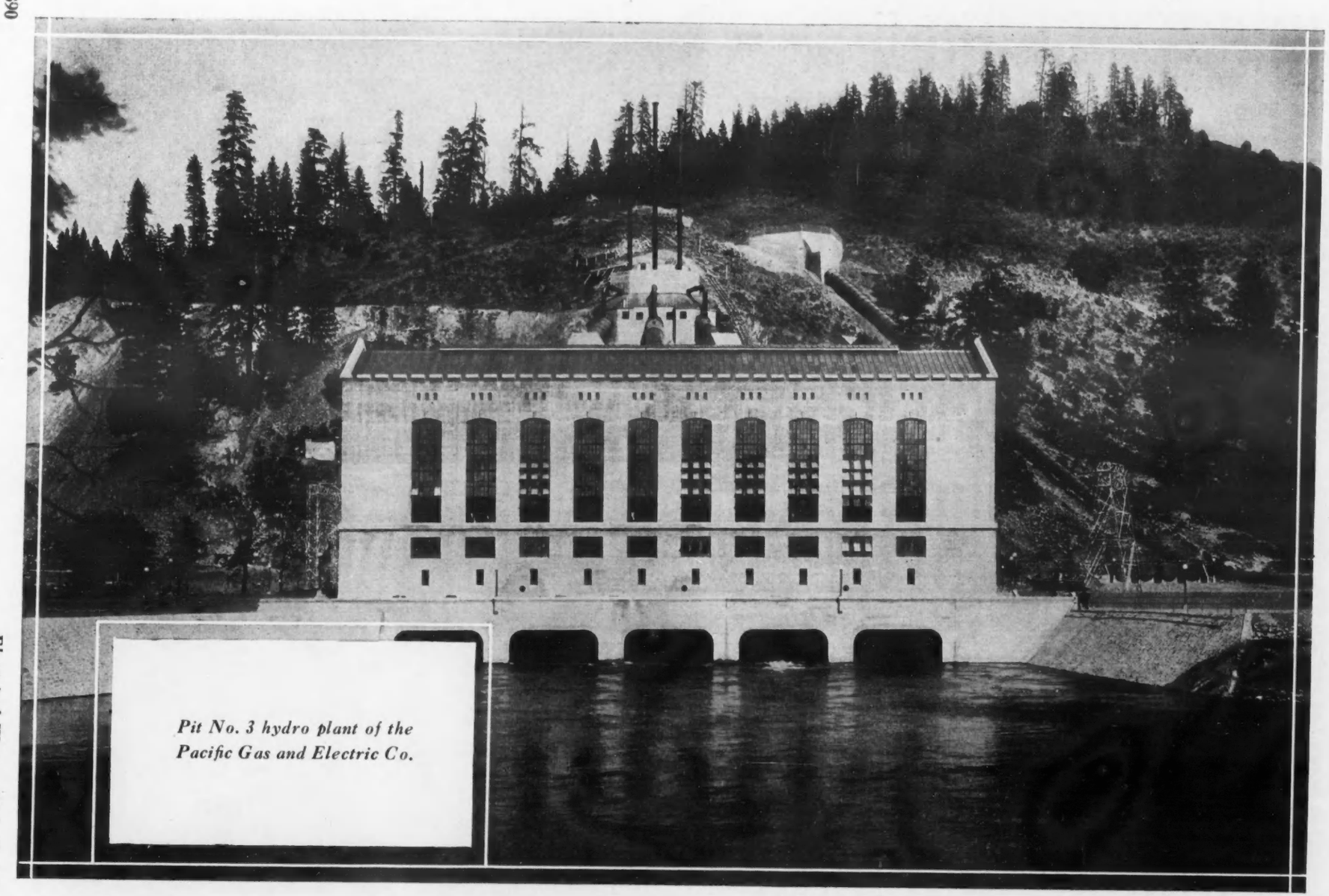
On The Southern Sierras Power Co. reservoirs, mercury gages have been installed, making for greater economy in use of water.

The Borel plant of the Southern California Edison Co. Ltd. has been rebuilt to replace two old units with one new one and to make the new one and the two remaining old units automatic. New governors were installed on the old units at the same time. The new unit is a 5,000-kw. turbine designed for a 254 ft. head, while the two old units were 2,000-kw. machines.

When the new governors were installed and the new unit tested, it was found that instead of 2,400 kw. output from old units, 2,650 kw. each was obtained and 5,800 kw. output from the new unit was recorded. Adding the saving in personnel because of automatic operation, a large return is obtained from the investment.

Numerous other installations can be cited to substantiate the saving in expense and increase in return, indicating by concrete examples that the field is fertile.

A continuation of work on this subject during successive years will no doubt develop interesting and valuable data.



Pit No. 3 hydro plant of the Pacific Gas and Electric Co.

METER COMMITTEE REPORTS[1]

*Checking Connections on Rkva. Meter Using a Voltmeter**

A method is described of checking connections to three-wire, three-phase Rkva. meters in which the only apparatus necessary is a voltmeter. It is necessary to know that the power factor of the load is lagging.

THE following method for checking and correcting connections on Rkva. meters requires no instruments other than a voltmeter, and applies to cases where the load is fairly well balanced. It is unnecessary to trace any wiring.

The basis of the check can be understood by an inspection of the vector diagram (Fig. 1) of the transformer used for securing the 90 deg. potential shift for Rkva. meters.

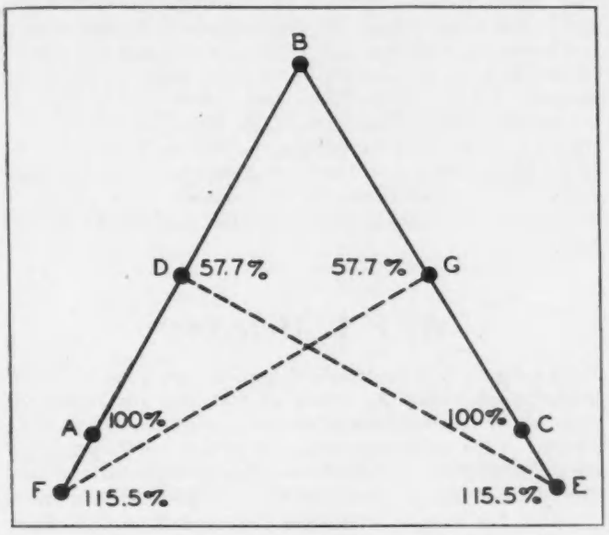


Fig. 1—Vector diagram of transformers used for securing the 90-deg. potential shift for Rkva. meters

The diagram shows the transformer vectors and the letters indicate how these voltages are applied to the meter potential windings. (Fig. 2.)

The vector (D E) is applied to one potential winding and vector (F G) is applied to the other potential winding. Both of these voltages are equal to the line voltage. It can be seen that a measurement between the potential terminals on the line side should show the vector (D F) to be 115.4 — 57.7 = 57.7 per cent of the line voltage and a similar measurement between potential terminals on the load side of the meter should show 115.4 — 57.7 = 57.7 per cent of line voltage. If the above conditions are satisfied, the only remaining connections which could cause improper registration would be the combination of the wrong current and voltage on the meter elements, or both potentials may be reversed. If the potentials were reversed, the meter would run backwards, while the wrong combination of voltage and current on the meter elements would stop the meter on balanced load.

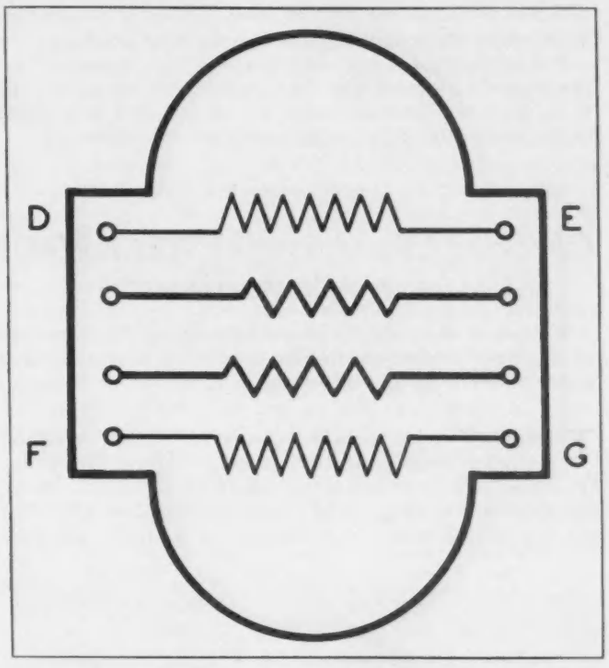


Fig. 2—Letters indicate how the voltages are applied to the meter potential windings

With these facts in mind, the following procedure will be self-explanatory and should form the basis of instructions to testers.

When the meter is properly connected, the voltage will measure as follows and the meter will run forward (referring to the meter diagram, Fig. 2):

Voltage between (D) and (E) terminals equals line voltage.
Voltage between (F) and (G) terminals equals line voltage.
Voltage between (D) and (F) terminals equals 57.7 per cent of line voltage.
Voltage between (E) and (G) terminals equals 57.7 per cent of line voltage.

If the above conditions are not satisfied, proceed as follows:

Step 1. Disconnect the potential wires from the meter and reconnect them to the meter so that: Voltage between terminals (D) and (E) equals line voltage, and voltage between terminals (F) and (G) equals line voltage.

Step 2. Measure voltage between (D) and (F) and also between terminals (E) and (G). If each of these voltages is not equal to 57.7 per cent of line voltage, interchange connections to terminals (D) and (E).

Step 3. (a) If the meter runs forward, the connections are now correct. (b) If the meter now runs backward, interchange connections to (D) and (E) again, also those to (F) and (G). (c) If the meter stops after step (3 b), interchange connections to (D) and (F), also those to (E) and (G).

If the meter runs backwards after step (3 c), interchange connections to terminals (D) and (E), also those to (F) and (G).

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* Prepared by M. A. Mason for the subcommittee on Rkva. metering, meter committee, Engineering Section. Wm. N. Lindblad, chairman. L. H. Beebe, M. A. Mason, G. H. Searle, J. H. Vivian.

If the above procedure has been carefully followed in the order indicated, it will now be found that the conditions outlined above for correct connections will be satisfied and the meter will give correct registration.

In the majority of cases it will be found that only one or two of the above steps will be necessary.

It should be noted that these tests are made with the assumption that the power factor is lagging. If there are large synchronous motors included in the load, the operator should be asked to reduce the field on them until it is certain that their power factor is lagging before the tests are made.

For convenience in making these tests, it is suggested that the tester be provided with four leads with a lug on one end to fit the meter terminal and a clip on the other end to clip to the wires after they are removed from the meter.

*Checking Connections on Rkva. Meter Using a Phase Meter**

Method of checking the proper phasing of Rkva. meters of all types is described. The apparatus necessary is a phase meter having a 360-deg. scale.

THE adoption by operating companies of rate schedules involving measurement of average power factor has introduced new problems for the meter departments. Many companies are making use of the measurement of Rkva.-hr., and one of the most vital problems is to devise a means of determining definitely that the Rkva. meter is correctly connected. This has been accomplished to a considerable degree by establishing standards of connection, and by checking connections after installation to determine that they have been adhered to and that phase sequence at the meter is correct for the standard connection.

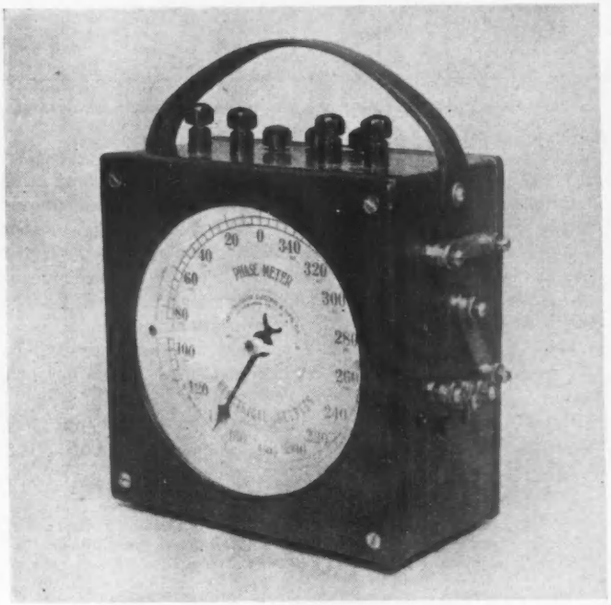

Fig. 1—Phase meter

Occasionally special conditions must be taken care of by unusual watthour-meter connections, and often no standard connection has been worked out for the Rkva. meter with such an installation. It then becomes necessary for the meter department to determine the proper connection and to be assured that it is correctly carried out.

A further duty of the meter department is to establish that the phase-shifting device ordinarily used with the Rkva. meter has correct internal connections.

These points may be checked by a simple test. The criterion of correct connections is that the potential applied to a given element of the Rkva. meter shall equal the potential on the corresponding element of the watthour meter, and shall lag the watthour meter potential by 90 deg. A voltmeter will, of course, establish the first point. The second is readily determined by means of an instrument known as a "phase meter," which is provided with current and potential coils, and which indicates, on a 360-deg. dial, the phase angle between current and potential. Such an instrument is shown in Fig. 1.

As the instrument requires a current of from 2 to 5 amp. for accuracy, it is usually best to use a resistance or phantom load rather than consumer's load. Taking current from any phase, the potential coil of the instrument is connected to one potential element of the watthour meter and the reading noted. It is then connected, in the same order, to the corresponding element of the Rkva. meter, and read again. As counterclockwise deflection from the zero position indicates that the current lags the voltage, the reading when connected to the Rkva. meter should be 90 deg. clockwise from the reading when connected to the watthour meter. It is, of course, essential to avoid crossing the potential leads between readings.

* Prepared by G. H. Searle for the subcommittee on Rkva. metering, meter committee, Engineering Section.

*RKVA. Metering**

The report of this year's committee on Rkva.-hr. metering supplements the report of last year by giving the practice of another one of the larger companies in California. This company makes a preliminary survey of each installation to ascertain whether it is to the consumer's advantage to apply for the power-factor rate.

After the meters have been permanently installed, an installation test is made, in which sufficient information is obtained to permit of making a complete vector analysis. Thus the meter engineer in his office checks the testman in the field, with the result that personal errors are eliminated.

THIS company installs Rkva.-hr. meters only where a preliminary survey has proven that the consumer will benfit by its power-factor rate. Up to the present time approximately 200 surveys and 150 permanent installations have been made.

The power factor survey is made by installing a temporary set-up consisting of a recording demand watthour meter, equipped with a ratchet and connected with phase-shifting auto-transformers so as to measure Rkva.-hr. The meter and phase-shifting auto-transformer are mounted and permanently connected in a weatherproof box. This makes the installation of a complete testing unit, which is moved from place to place. The unit is connected in series with the permanently installed watthour meter which is also of the recording demand type. The survey or test is made over a period of not less than ten days. From the information obtained, the commercial department decides whether or not the consumer will benefit by taking advantage of the power-factor rate.

The surveys are made by the meter test department, but the permanent installations are made by the district meter

* Prepared by L. H. Beebe for the subcommittee on Rkva. metering, meter committee, Engineering Section.

setters under the supervision of a meter testman. Testmen are required to turn in data called for in Fig. 1. Fig. 2 represents a typical report on a permanent installation.

The numbers shown in circles on the sketch of the MC-7 auto-transformer and on the vector diagram for the same refer to the electrical phase rotation, while the other numbers are those supplied by the manufacturer. Four different makes of auto-transformers have been used by this company and no standard phase rotation has been adopted.

The phase angles are measured with a portable phase indicator having a 360-deg. scale. The values recorded on Fig. 2 are the angles by which the current leads the respective voltage vector. The vector diagram on this sheet has been made to show the relations that would exist at unity power factor.

Fig. 3 shows how the meter engineer in the office checks the testman's report. The phase angles obtained from test and recorded on sheet No. 2 are laid out on sheet No. 3 by means of a protractor.

The voltage vector E_{1-2} is arbitrarily given a vertical position and the vectors E_{2-3} and E_{3-1} located in their respective positions to indicate a balanced three-phase circuit. The position of current vectors I_1 and I_3 is determined from the first set of phase-angle readings with reference to the fixed position of 1-2 and 3-2, respectively. The remaining angles are laid out with reference to the current I_1 or I_3 as the case may be. The vectors linked together show the potentials used with the same current. For example: with current I_1 potential 1-2 is used on the kw-hr. meter and potential 6-7 on the Rkva.-hr. meter, and for current I_3 potential 3-2 is used on the kw-hr. meter and potential 4-5 on the Rkva.-hr. meter. The phase-angle readings available give us two opportunities to locate each of the above potentials. The small discrepancies are apparently due to the extra burden imposed by the phase indicator, variations in load during test, scale and personal error.

The final installation is tested over-all as a watthour meter. All testing work is done by experienced men who understand the reading and drawing of vector diagrams.

Data Desired on Reactive KVA Installations
1. Phase Rotation
3 2 1
Show actual connections to give c.c.w. rotation on meter.
2. Voltage balance 1-2, 2-3, 3-1.
3. Voltage on reactive meter 4-5, 6-7.
4. Wiring of kw and reactive kva meter (front view)
5. All meter data including potential transformer and current transformer ratios.
6. P.F. from ratio of individual elements of kw meter.
7. P.F. from ratio of reactive kva-hrs. to kw-hr. (use curve or table)
8. Rev. and time of kw meter (at least 60 seconds)
9. Rev. and time of reactive kva meter (at least 60 seconds)
10. Phase angles between currents I_1 and I_3 and pot. coil voltages of both kw and reactive kva meters.
(I_1 to represent low reading phase and I_3 high reading phase at lagging power factors on 3 phase 3 wire installations. Vice versa on 3 phase, 4 wire installations).
11. If possible to determine, note if power load is balanced or unbalanced. Note secondary current in meter elements.
12. On installations using G.E. MC-7 transformers, designate rotation 1-2-3 and actual markings on transformers.
13. All vectors should be based on following fundamental rotation.
1-2
3-1
2-3

Fig. 1—Data to be turned in by testmen

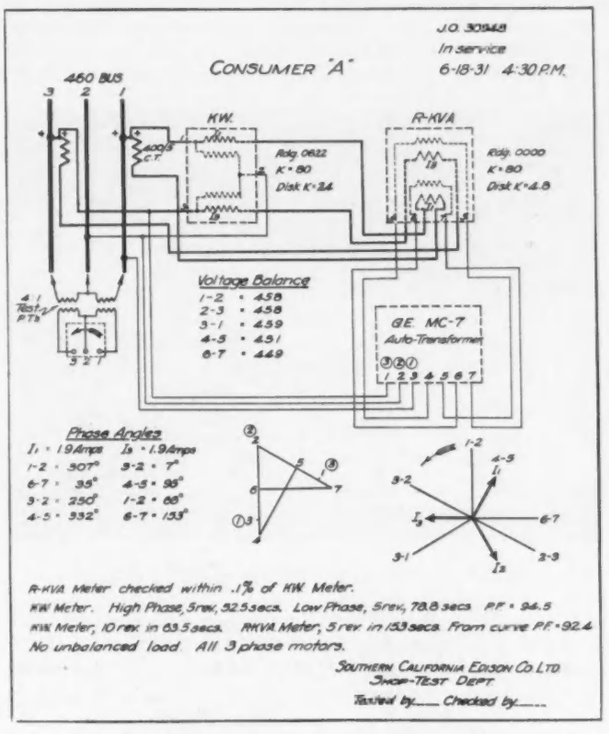

Fig. 2—Typical report on permanent installation

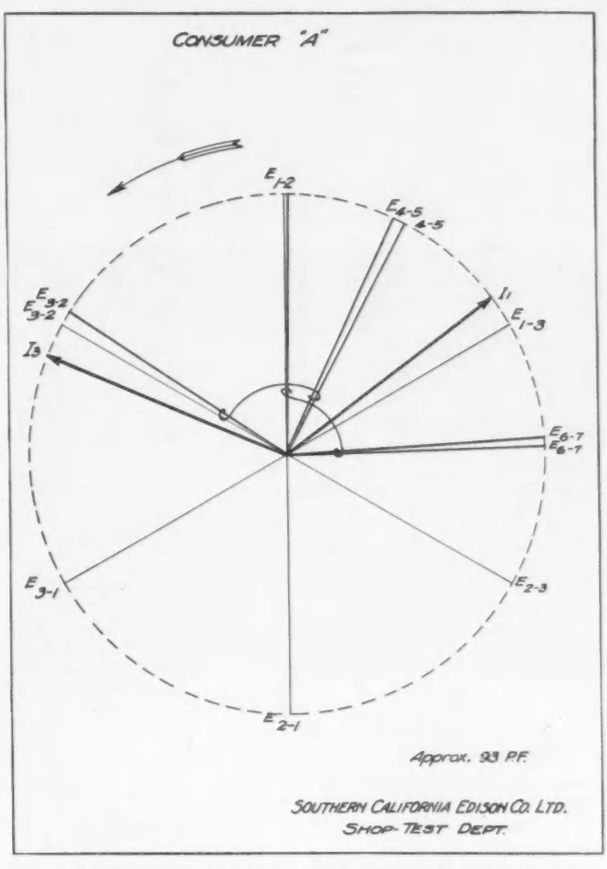

Fig. 3—Check of testman's report by engineer in office

*Report of Subcommittee on Special Tests and Investigations**

Time Interval Apparatus[1]

A brief description of a method of utilizing a constant regulated speed-time source of energy, operating synchronous rotating equipment, to provide the time intervals involved.

IN THE process of standardizing rotating testing equipment, the importance of the time interval over which the test meter is to be run for a given load point is apparent from the power equation:

$$W = \frac{R \times K \times 3{,}600}{T}$$

where W = power in watts
R = revolutions of the test meter
K = watthour constant of test meter
T = time in seconds.

from which a transposition of terms provides the time interval in question.

$$T = \frac{R \times K \times 3{,}600}{W}$$

The time interval (T) and the power (W) being major factors subject to the personal errors of the testmen, every effort is made to eliminate these variables, thereby increasing the accuracy of the certification for the equipment under test.

The true power (W) being the major objective of the test, the time interval (T) is usually calculated as a secondary factor depending on the revolutions of the test meter disk. The revolutions are usually arbitrarily selected to permit simple relations with respect to the test meter constant and the load point in question.

In most cases, the time intervals involved for a given test can be readily reduced to two points, viz: 120 sec. for 50 to 100 per cent loads, above 86 per cent power factor; and 240 sec. for loads less than 50 per cent and at low power factors; which, under ordinary conditions, permits a sufficient number of disk revolutions to reduce the error of the smallest dial division to a comparatively small value.

Several timing devices are in use which employ a second-beating master clock, with various methods and adaptations of relays, for the test-meter potential circuit control. Many of these have given quite satisfactory results; however, certain limitations, such as constant power supply, delicacy of relays, and the accuracy of the standard clock, often present some problems which require considerable attention over long periods of use.

It is the purpose of this outline to describe a method of utilizing a constantly regulated "speed-time" source of energy, operating synchronous rotating equipment, to provide the time intervals involved. In this method the functions are accomplished through the use of rotating-speed time, thereby eliminating many delicate relays and controls involved in the use of oscillating-pendulum time.

The apparatus herein described was manufactured by the Leeds and Northrup Co.; some modifications to their regular time-interval apparatus were made to meet certain requirements of the standardizing laboratory of the shop-test department of the Southern California Edison Co. Ltd. at Alhambra.

This method involves the use of:

(a) tuning fork
(b) rotary converter
(c) transformer

as the means of supplying the constant regulated a.c. source for speed-time, and

(d) synchronous-motor-driven disk
(e) relays
(f) control switches

as the means of transferring speed-time to the desired time interval for the control of the test-meter potential circuits.

The operation of this device utilizes a d.c. source of less than 1,000 watts at 110 volts as the supply for the rotary converter and the actuating coil of the tuning fork. This supply may vary 5 per cent above or below the nominal voltage without causing the rotary converter and tuning fork to slip out of synchronism. Suitable rheostats are provided for operation of the device through a range of 95 to 125 volts.

The electrically driven tuning fork automatically maintains a constant speed of the armature of the rotary converter, by the use of a vibrating contactor on one prong of the tuning fork which either increases or decreases the strength

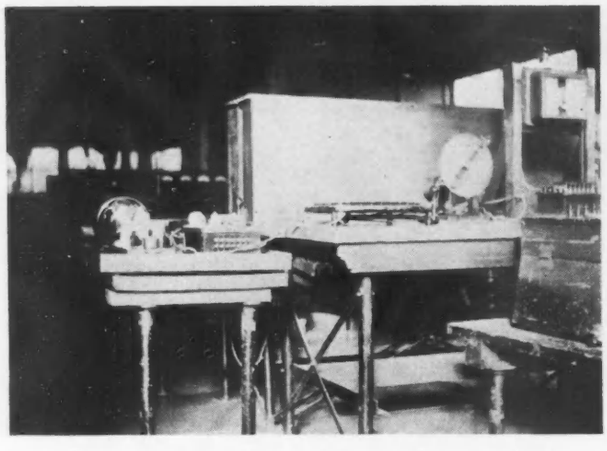

Fig. 1—Arrangement of apparatus in use during a test

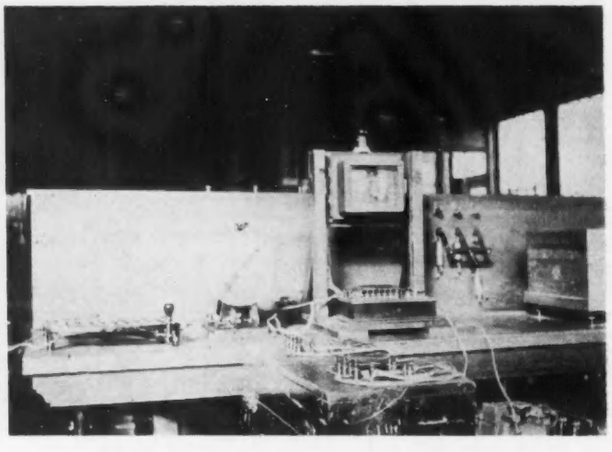

Fig. 2—Near view of apparatus shown in Fig. 1

of an auxiliary control field in the rotary converter. The strength of the auxiliary control field being a function of the rectified alternating potential obtained by a circuit completed through the center tap on the secondary of the 75 to 110-volt transformer, which is energized from the slip rings of the rotary converter, it therefore provides an electrically coupled

* Report of subcommittee on special tests and investigations, meter committee, Engineering Section. Lester L. Conrad, chairman. R. G. Jones, O. A. Knopp.

[1] Contributed by Lester L. Conrad for the subcommittee on special tests and investigations, meter committee, Engineering Section.

relation between the frequency of the converter and the period of the tuning fork and consequently furnishes a rotary motion of constant angular velocity, supplying an alternating current of constant frequency. The range of placement of the weights on the prongs of the tuning fork provides frequencies from 25 to 65 cycles, thereby supplying energy

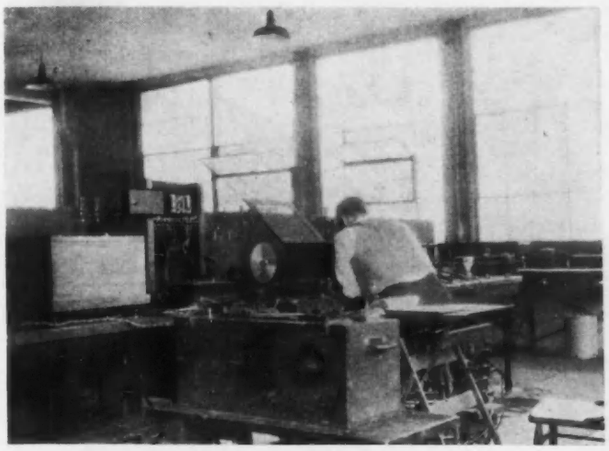

Fig. 3—Test in progress

which can be utilized electrically for investigations involving constant frequencies and mechanically through the synchronous-motor-driven disk for investigations involving time intervals.

The time-interval device utilizes a 1/10-hp. 110-volt synchronous motor, energized from the a.c. output of the rotary converter, driving a 9-in. disk through suitable gears to provide one revolution of the disk in either one minute or in two minutes.

The disk is equipped with two contact-operating fingers projecting beyond the edge of the disk, one attached permanently on the disk edge, the other mounted on a movable arm which, when released, may be set at any one of the 30 equi-spaced notches, six degrees apart, machined in the edge of one-half of the periphery of the disk. A vernier adjustment provides a further setting of one-twentieth part of the space between two notches. Therefore, at a disk speed of one revolution per minute, each machined division represents a time interval of one second, and each vernier subdivision corresponds to an interval of 0.05 second.

The constant angular velocity or speed-time of the rotating disk is transferred into time intervals through the two contact operating fingers which, when passing, depress two trip keys mounted on the case. These trip keys operate two relays, through which the potential circuits to the test meters are either energized or de-energized. Large contacts are provided on the trip keys and relays. Adjustments are provided for compensation where necessary, and all moving parts are readily accessible for inspection and maintenance.

The same sequence of operation is accomplished through the use of one seven-pole, double-throw manually operated switch, and one single-pole double-throw momentary-contact reset key, thereby subjecting the same uniform time delay in the operation of de-energizing the potential circuit as was introduced during the operation of energizing the potential circuit.

This apparatus has been used in several test-meter standardization tests with entirely satisfactory performance, eliminating the personal errors heretofore accompanying the use of hand-operated potential circuit control.

A further application of the constant-speed and frequency apparatus is now contemplated, to supply a source of constant potential and constant frequency for standardization circuits.

This adaptation involves a three-unit motor-generator set, consisting of two 10-kva. sine-wave a.c. generators driven by a 15-hp. d.c. motor. The a.c. generators are to be 6-pole, 1,000 r.p.m., to supply 115-230 volts, three-phase at 50 cycles. One generator will be equipped with a movable stator mounted on a rack and pinion, motor-operated, through 120 electrical degrees to provide the proper phase displacement from the output of the generator with the fixed stator, thus permitting various power factor conditions.

The speed of the d.c. driving motor will be under constant automatic control through the adaptation of the Leeds and Northrup tuning-fork and rotary-converter equipment. The rotary converter is to be mounted upon the frame of the three-unit set and will be driven as a double-current generator through suitable gears and a silent chain to supply the field excitation of the d.c. driving motor.

The field of the rotary converter and the actuating coil of the tuning fork will be excited from the same source as that impressed on the armature of the d.c. driving motor. The auxiliary control field of the rotary converter will also be excited from the main d.c. supply, but will be controlled through the contacts mounted on the prongs of the tuning fork and through the alternating current generated by the rotary converter as outlined above. Thus the speed of the main d.c. driving motor is kept constant in a definite relation

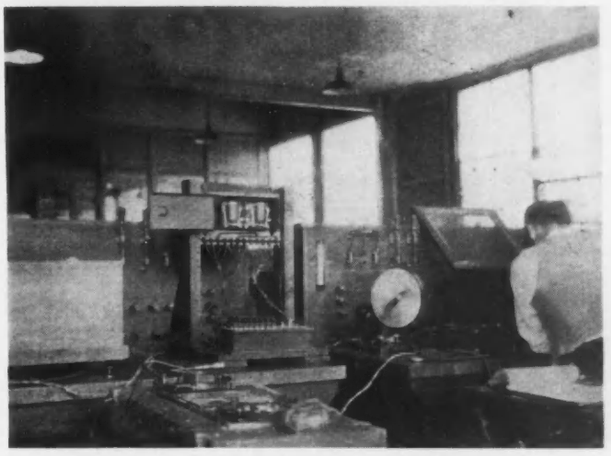

Fig. 4—Closer view of test

to the oscillating period of the tuning fork as determined by the placement of weights on the prongs of the tuning fork.

As the range of placement of the weights on the tuning fork is ample to provide oscillating periods or frequencies from 25 to 65 cycles, it is reasonable to assume that the three-unit set will be kept at a constant speed in that range according to the placement of the weights and consequently a source of constant potential at a constant frequency may be expected.

Vibration Recording Device[2]

In making field tests on several types of vibration dampers for transmission-line conductors, it was found that the vibration of the conductors occurred usually at night, which necessitated the use of recording instruments. It was desired to record the amount of vibration of the conductor, the direction of the wind with respect to the line, and the velocity of the wind. As there were no instruments existing for this purpose, it was necessary to make an instrument to meet the requirements.

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[2] Contributed by Otto A. Knopp for subcommittee on special tests and investigations, meter committee, Engineering Section.

THIS instrument was devised to record simultaneously wind direction, wind velocity, and conductor vibration on high-tension transmission lines. Its mechanism is mounted in a metal recording millivoltmeter case and is described as follows: The wind direction through 90 deg. is obtained by a wind vane turning a cam, which, through a system of levers, moves a stylus on the chart. The vane is set so that a wind parallel to the line causes the stylus to be in a minimum position, and a wind at right angles to the line causes the stylus to be at a maximum position. Wind velocity is obtained by causing the stylus to move from its indicating

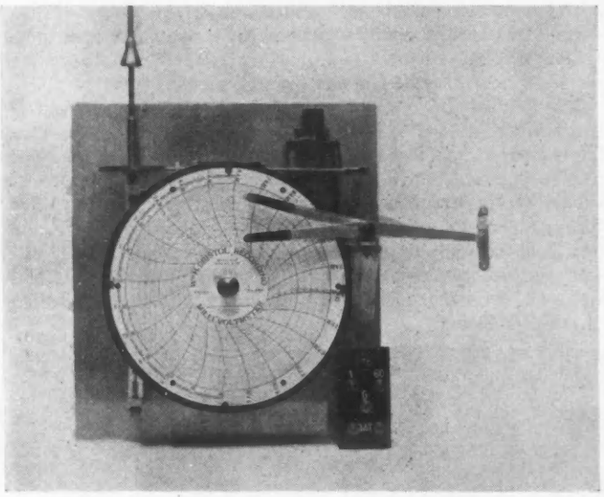

Fig. 1—Close-up of operating mechanism of recorder

position to a position about ¼ in. beyond the maximum position of the direction indication. This motion is actuated by a cup-type anemometer having contacts that make and break for every mile of wind. The motion of the stylus is caused by a small solenoid, connected up with an instantaneous relay. The stylus is mounted so as to follow the time curve of the chart. Wind velocities are obtained, therefore, by counting the number of mile-indications over a given time period.

The vibration of the conductor is reproduced on the chart by means of a lever pivoted at the center and having, at one end, a stylus which touches the chart on the same time-line as the stylus indicating wind direction. The other end of the lever is connected to the conductor by means of a paraf-

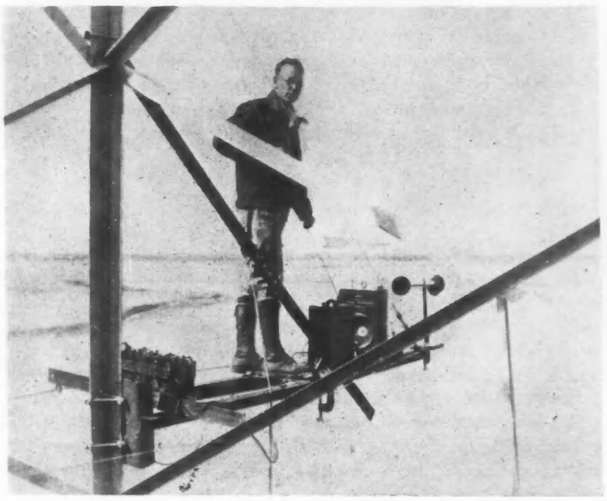

Fig. 2—Recorder mounted on an outrigger on the transmission tower, together with anemometer

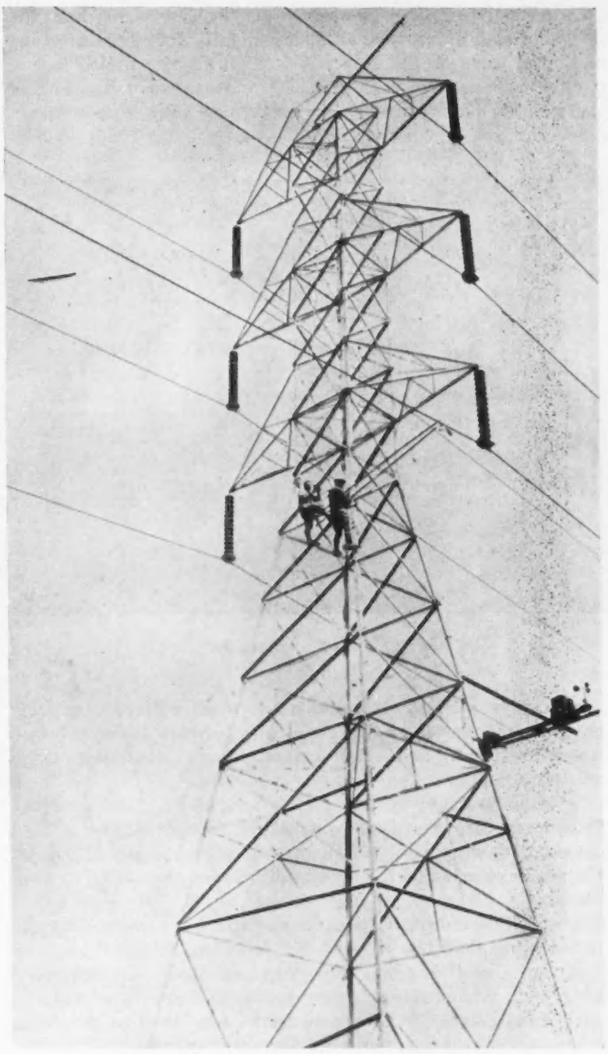

Fig. 3—Mounting on transmission tower

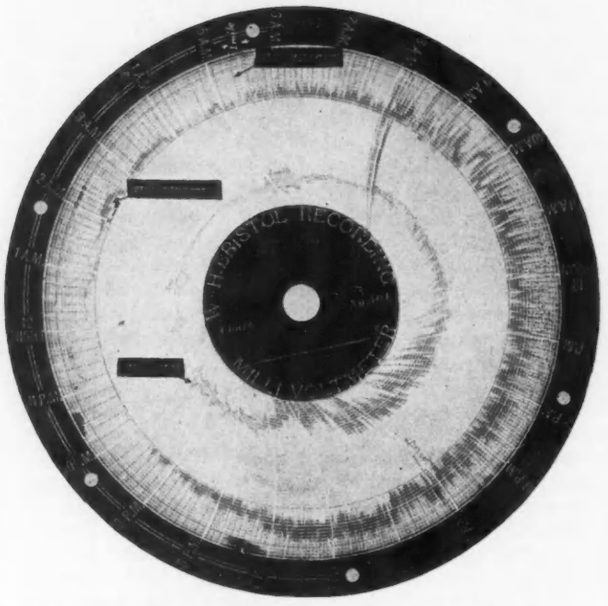

Fig. 4—Chart taken on a transmission line for a 24-hr. period

fined string. A light coil-spring is used to balance the tension of the string, in order to hold the stylus at the center of its range.

The charts used with this instrument are recording millivoltmeter smoked charts. The upper, or outer, half of the chart is used for the wind direction and velocity stylus, while the lower, or inside, half is used for recording vibration.

The vibration of large (1-in.) conductors varies from 0 to ¾ in. in amplitude and from 10 to 20 cycles per second in frequency. A combination 12-hr. and 24-hr. clock movement is used and, because of its slow speed, the vibration stylus traces a solid envelope on the chart from which amplitude measurements only may be obtained.

Fig. 1 shows a close-up of the operating mechanism of the recorder. Figs. 2 and 3 show the recorder mounted on an outrigger on the transmission tower together with the anemometer. Fig. 4 shows a sample chart taken on a transmission line for a 24-hr. period.

Loading Transformer for Relay Testing[3]

A description of a method, using an inexpensive loading transformer, for testing operation of a.c. overcurrent relays in connection with reactors.

THE policy of the San Diego Gas & Electric Co. in the last few years has been to conduct periodic inspections of electrical switchgear equipment several times each year, in addition to periodic testing of relays. These inspections consist of tripping O. C. B. electrically by functioning a.c. protective relays with a loading transformer. Tests are conducted in an operation sense only, no consideration being given to the degree of accuracy of relays or switch time operation. The average phantom load is most satisfactory

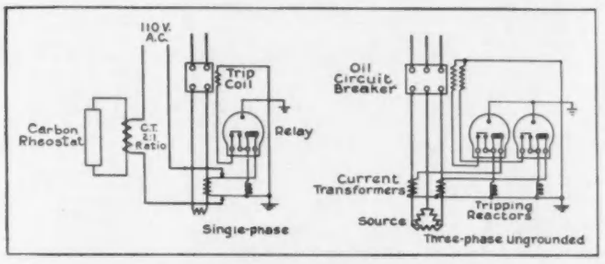

Fig. 1—Diagram illustrating inexpensive device suitable for testing operation of a.c. overcurrent relays in connection with reactors

for this work, except where protective equipment consists of a.c. transfer overcurrent relay protection, including reactors.

The following diagram illustrates a very suitable inexpensive device for this work, constructed from an ordinary stock current transformer, 2/1 ratio, approximately 0.400 volt-amp. capacity, and a small carbon or wire rheostat of low resistance. The rheostat is for the purpose of regulating current flow in the relay circuit. This method has been used by this company for several years with good results.

[3] Contributed by W. H. Talbott for the subcommittee on special tests and investigations, meter committee, Engineering Section.

Measurement of Spot Temperatures in Relays[4]

A method of measuring spot temperatures in relays is described.

[4] Contributed by W. H. Talbott for the subcommittee on special tests and investigations, meter committee, Engineering Section.

SOME time ago it was considered advisable to conduct a heat run on a new type of relay to determine the maximum current-carrying capacity. It was necessary to determine the absolute temperature and also the temperature rise for several different parts, with the cover in position. The problem resolved itself into two parts, (a) temperature control of the surrounding air and, (b) measurement of the chosen spot temperature.

The control of the surrounding air temperature was a simple matter, as the relay was mounted on a small panel and placed inside an inclosed hood. Electric heaters were placed in the remote ends of the hood, arranged so that the head blast would be diffused and not reach the relay directly, and vents in the top of the hood permitted a nicety of control.

As it was desired to measure temperature rise with the relay cover in position, the use of ordinary thermometers was out of the question. It was decided to use the resistance thermometer method, and small copper coils were constructed and calibrated by submerging them in an oil bath. Resistance measurements were made at three or more temperatures, and the constants of each coil determined. The calculations were based upon the accepted formula:

$$\frac{Rt_1}{234.5 + T_1} = \frac{Rt_2}{234.5 + T_2}$$

Where: Rt_1 is the resistance in ohms, corresponding to a temperature of T_1 in deg. C., and
Rt_2 is the resistance in ohms corresponding to a temperature of T_2 in deg. C.

Transposing and rearranging:

$T_2 = KRt_2 - 234.5$
Where K is the individual coil constant (including lead resistance).

Similarly:

$T_1 = KRT_1 - 234.5$
From which, each coil constant (K) is determined. (See Table I for typical results.)

TABLE I

Coil No. 2 Rt_1	Oil Bath T_1	Constant Determination
Ohms	Deg. C.	K
1.567	23.3	164.4
1.5775	24.7	164.3
1.874	78.6	167.1
2.002	99.9	167.1
2.026	100.2	165.5
	Mean	165.7

The coils were mounted on the parts designated, using a small amount of oil-putty, and the test started by holding a constant current and voltage on the proper relay elements. The test was continued until three successive resistance measurements, taken at half-hour intervals, showed no increase in temperature in any of the temperature coils.

After the test was completed, the temperature coils were removed and check calibrations of the coils were made, using a hot oil bath at approximately the maximum temperature measured during the heat run. In all cases the results seemed to be consistent and within the limits of accuracy to be expected.

Resistance measurements were made using a standard commercial type of Wheatstone bridge.

The chief advantages of the method are:

1. Standard electrical laboratory equipment is used throughout.
2. Results obtained are reliable.
3. The method is inexpensive.

*New Meter Developments**

A summary of new devices recently put on the market or now under development.

* Report of new developments subcommittee, meter committee, Engineering Section. C. F. Gilcrest, chairman. W. R. Frampton. Acknowledgement is made to the Duncan Electric Company, the General Electric Company, Leeds & Northrup Company, States Company, Sangamo Electric Company, Westinghouse Electric & Manufacturing Company, also to O. A. Knopp and E. L. Hughes.

Duncan Electric Company

THIS company reports that single-phase watthour meters are now in production with studless-type cover. The metal band holding the glass is made of brass to prevent rusting.

They also announce that the binding posts of 15-amp. and 25-amp. meters have now a 5/16-in. hole to receive leads and that double clamping screws are used.

The phasing plate has been replaced with a lag coil having adjustable resistor. This permits a meter to be calibrated on 50 or 60 cycles without change of parts.

General Electric Company

1. The shank of the thimble supplied with 25-amp. and 50-amp. watthour meters has been shortened by ⅛ in. This prevents the possibility of sliding up the insulating bushing and exposing the metal.

2. Instead of white-enameled face registers a direct-printed aluminum-finished register is supplied.

3. The factory has begun to supply watt-hour-meter disks with 720 indentations around the circumference, for use in stroboscopic testing.

4. An improvement is reported in the blending of the oil for lubrication of meter jewels, whereby satisfactory operation is secured for a longer period of time.

5. A micrometer full-load adjustment is now supplied on watthour meters.

6. Announcement is made that the LFM-1 current transformer for three-wire service is now in production. This equipment enables higher accuracy to be secured on light secondary burdens than with the older WCM-12 type.

7. The KT time meter is a recent development. A counter records "elapsed time" in minutes, tenths of hours, or hours. It may be secured for 115, 230, or 460-volt circuits. (See Fig. 1)

8. The type-TPC timing device is an improvement on an older relay for a similar purpose. A Warren motor actuates the timing element, instead of the spring clock used previously. Intervals of ½ sec,, 1 sec., 1 min., or multiples of a minute may be secured. (See Fig. 2)

9. The PM-13 A1 automatic oscillograph has been devised to supply required information covering operation of transmission system relays and switches. The equipment records six variables and starts from 0.002 to 0.004 sec. after the initiating quantity. The standard operation portrays a cycle per 1/5-in. of chart. (See Fig. 3)

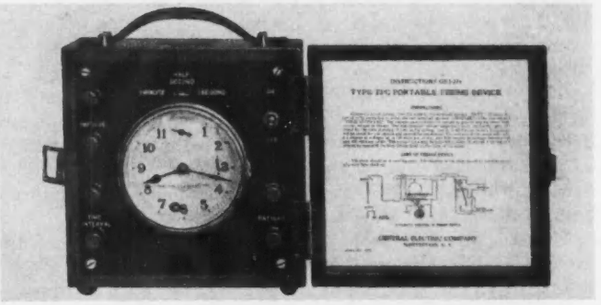

Fig. 2—Type-TPC portable timing device, General Electric Company

10. A new portable a.c. current test-set is announced. This consists of a split-core current transformer and a double-range ammeter. Standard ratings are 50-125 amp. and 125-

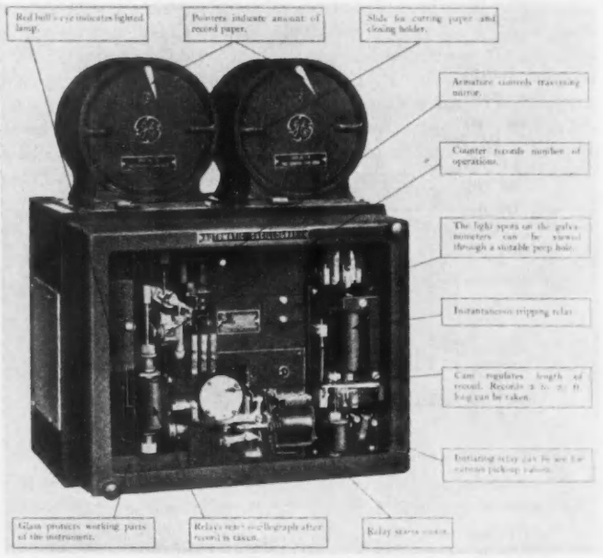

Fig. 3—Type-PM-13-A1 automatic oscillograph, front view, General Electric Company

Fig. 1—Type-KT time meter, General Electric Company

Fig. 4—Portable testing kits, General Electric Company

500 amp. Tests have shown good results for this type of equipment. (See Fig 4)

11. A modification has been made in the leads between the terminals of the meter and the coil terminels of D-14 and D-15 watthour meters. Instead of the enameled wire formerly used, a round insulated lead is now provided in 15-amp., 25-amp., and 50-amp. meters.

12. The type D-14 MW watthour demand meter is a self-contained combination watthour meter and demand meter of the two-element type for use on three-wire, two-phase or three-phase; or four-wire, two-phase circuits. The device is installed in a base of the same size as the three-element polyphase meter. (See Fig. 5). The D-15 MW watthour demand meter is similar to the above, except that it is a three-element instrument. It is in the same base as the D-14 MW meter, but a cover is used which is 1¼ in. deeper than the standard.

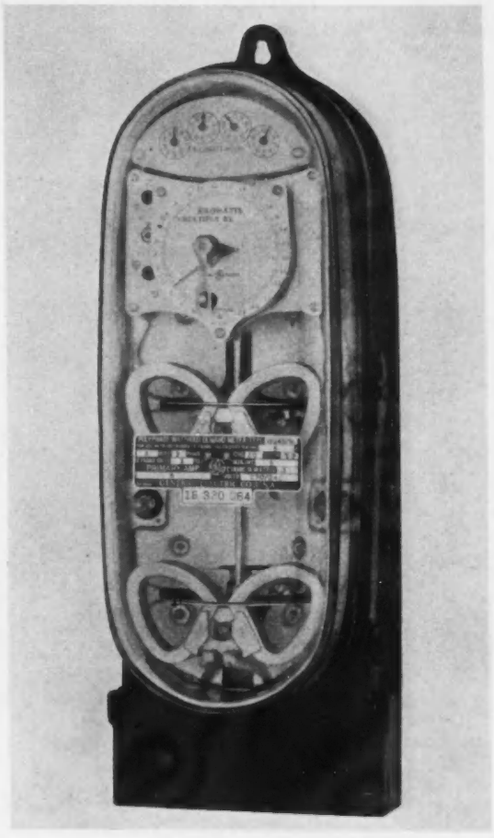

Fig. 5—Type-D-14-MW polyphase watthour demand meter, General Electric Company

13. A change has been made in the chart-drive mechanism of CD instruments. A separate spring has been added to drive the reroll so that the clock is called on for timing duty only. Complete particulars are contained in bulletin G.E.A. 1061D.

Leeds and Northrup

1. Equipment is available for checking potential transformers up to 125-kv. high voltage rating. The method employs a no-loss high-voltage parallel-plate air condenser equipped with suitable guard circuits. (See Fig. 6). The auxiliary apparatus consists of adjustable low-voltage condensers, a compensating and current limiting box, resistance units, a mutual inducto-meter and a suitable detector.

2. A change is announced in the construction of the Brooks Model 8 deflection potentiometer. Heretofore this instrument has been designed for 150-millivolt capacity, the volt-box resistance approximating 40 ohms per volt. Under some circumstances, correction was required to compensate for volt-box losses. The new design alters the capacity of the instrument to 1.5 volts and increases the volt-box resistance per volt to 500 ohms, the previous inconvenience then being eliminated. (See Fig. 7).

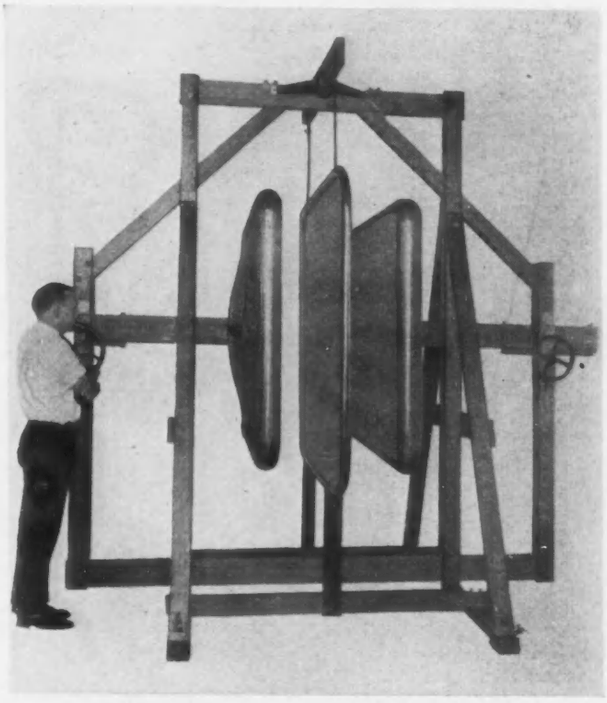

Fig. 6—Zero-loss, high-voltage, parallel-plate, guarded air condenser, Leeds and Northrup Company

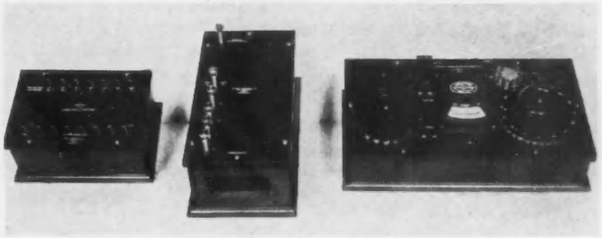

Fig. 7—Brooks model-8 deflection potentiometer and accessories, Leeds and Northrup Company

3. A new improved balancing mechanism has been prepared for use on all models of recording instruments. This is known as the micromax recorder. The advantages claimed for this equipment are greater sensitivity, rapid recording, and mechanical simplicity.

One recent application of the micromax recorder was in conjunction with a Lincoln thermal recorder for measurement of power.

Another installation involved a voltage record from a Wheatstone bridge connection. (See Fig. 8).

The States Company

1. Type-N test blocks are particularly designed for electric range and water heater installations. The block is very

compact and requires the manipulation of only one hex nut per pole instead of the usual two. (See Fig. 9).

2. A portable meter test kit—consists of a fiber case 19x10¾x10 in., containing a built-in load box and spaces for test meter, leads and customary tools. The maximum current capacity is 25 amp. (See Fig. 10).

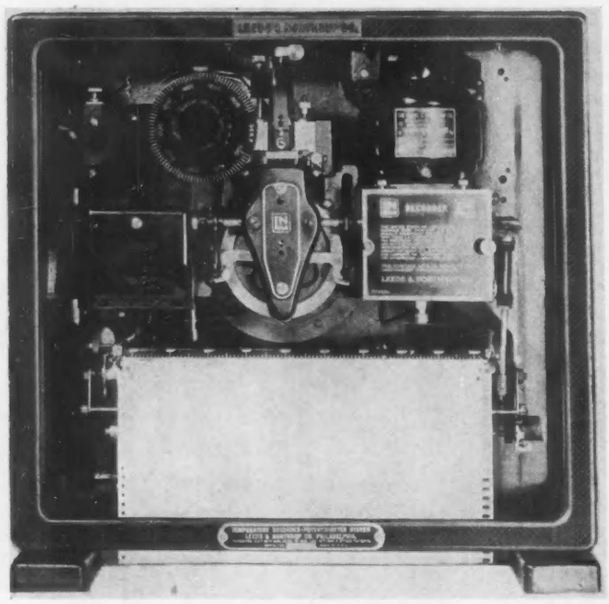

Fig. 8—Micromax recorder, Leeds and Northrup Company

3. The Ohmspun relay load is an assembly of resistances and control switches arranged to facilitate the testing of relays. (See Fig. 11).

Sangamo Electric Company

1. Type-HC watthour meters are shortly to be furnished with studless glass covers. Sealing arrangements are similar to other types now on the market.

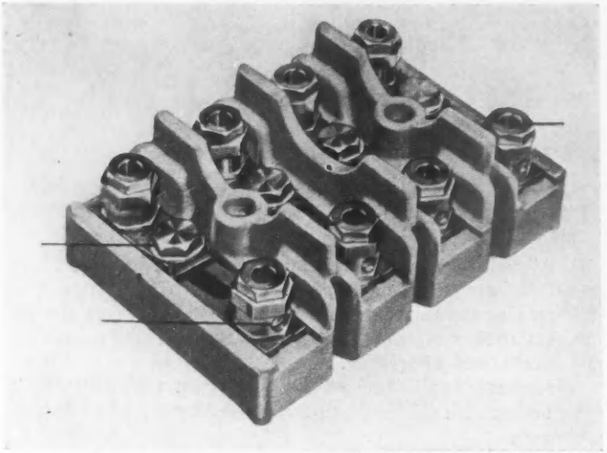

Fig. 9—Type-N test block, The States Company

2. A moulded terminal block has been designed for use on HC watthour meters. This design improves the terminal insulation and is of the standard dimensions and terminal arrangement established by the N.E.L.A. meter committee.

3. Five-wire two-phase type-HC watthour meters are available. This instrument is supplied with or without potential indicating lamps.

4. Horizontal polyphase back-connected meters have been produced by adding brass studs to the house type. The studs are brought out through insulated holes in the back of the terminal chamber.

5. A contact mechanism for watthour meters has been designed so that it is completely assembled on the register supporting bracket.

6. The company is prepared to supply an alarm contact for HB demand registers. This device will operate an alarm circuit whenever the demand reaches a predetermined value.

7. The Type-CS potential transformer is announced for use on 460-volt 60-cycle circuit. Both primary and secondary terminals are inclosed in bakelite blocks.

8. The Sangamo Company has entered into agreement with Venner Time Switches, Ltd. of London whereby the former will manufacture and sell this equipment in the United States. The Venner Co. also makes a stop watch which may prove of interest to the instrument testers.

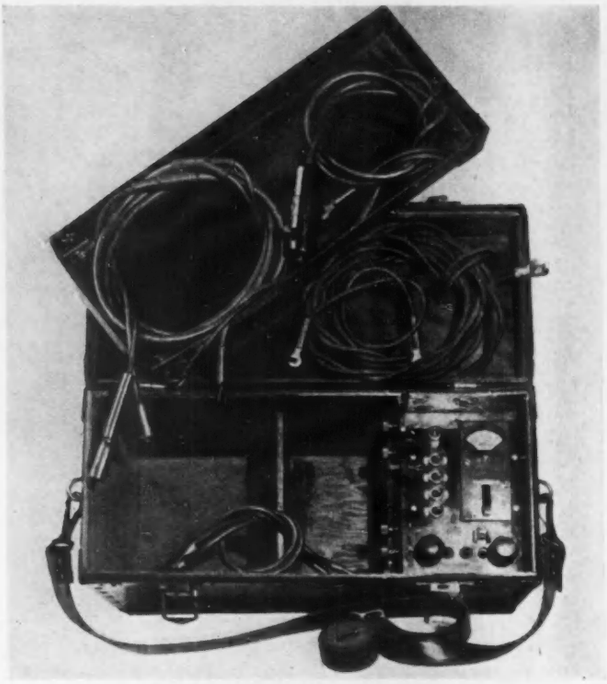

Fig. 10—Portable meter test kit, The States Company

9. A Lincoln circular chart graphic is available in watt-demand, volt-ampere-demand (using phase-shifting transformer) and ampere-demand types. The charts are 8 in. in diameter.

The timing device may be either a spring-drive clock or a synchronous-motor element. One revolution of the chart is obtained in 2, 8, 16, or 32 days. (See Fig. 12).

10. A special type of A.D. demand meters has been prepared for use on a.c. three-wire single-phase circuits. With this instrument it is not necessary to put the neutral lead through the instrument, as is the case with the meter which is used interchangeably on a.c. and d.c. circuits.

11. A new moderately priced time switch is announced. The Model B, Form VW is an electrically wound spring-driven mechanism. The Model B, Form VS is driven by a synchronous motor. These switches can perform three "on" and "off" operations per 24 hr. Sunday and holiday cutout is provided. (See Fig. 13).

WESTINGHOUSE ELECTRIC & MANUFACTURING CO.

1. The Emeryville meter shop of this company has recently assembled a duplex OB meter which indicates kw.-hr., Rkva.-hr., and the kw. demand. The auto-transformers for the reactive element, as well as a testing switch, are located in the same case.

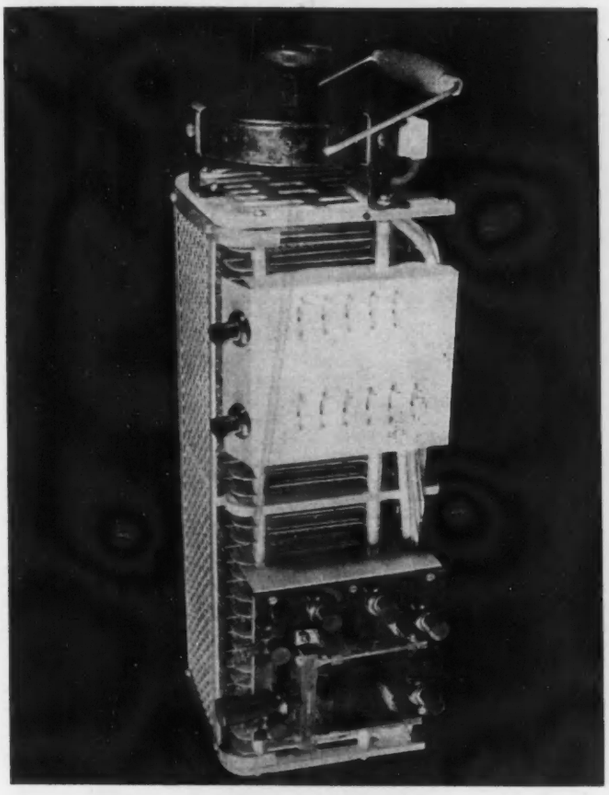

Fig. 11—Ohmspun relay load, The States Company

2. Fig. 14 shows the Type-A graphic instrument mounted in a sheet metal box which protects it from the weather and also provides space for ink bottle, spare charts, etc.

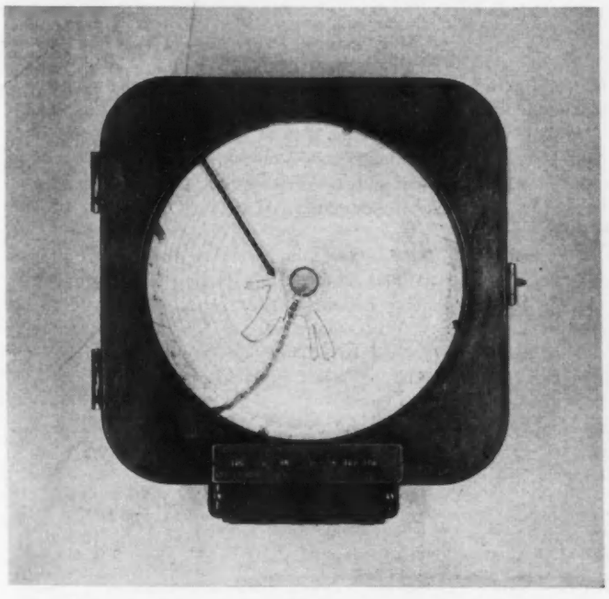

Fig. 12—Lincoln watt demand graphic meter, Lincoln Meter Company, Inc.

3. A portable stroboscopic meter-testing set is illustrated. This arrangement has a dial whereon the error is read directly. Meters which are not equipped for stroboscopic testing may be tested by using the rotating standard element in the usual manner. (See Figs. 15 and 16).

4. Several changes are announced in the OB demand regis-

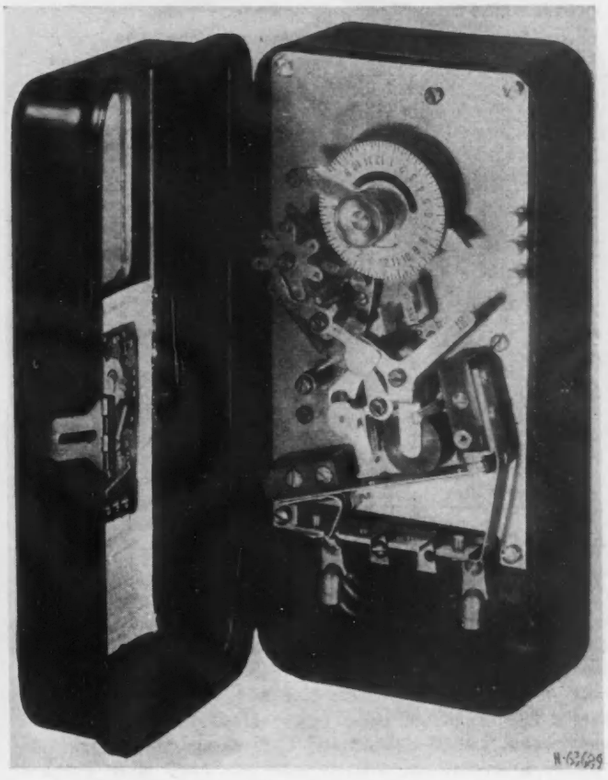

Fig. 13—Model-B, form VW time switch, Sangamo Electric Company

ters. The gravity-reset feature has been eliminated, as well as the worm and sector for demeshing the demand gearing. The resetting is now a spring function. A slight change has been made in the OB synchronous motor and it is used also in the RA, RI, and RB meters and clocks. An adapter mounting has been prepared so that the largest type-OB demand register may be used on OA meters. Apparently this would also call for a change of the meter cover on account of the difference in the setback device. (See Fig. 17.)

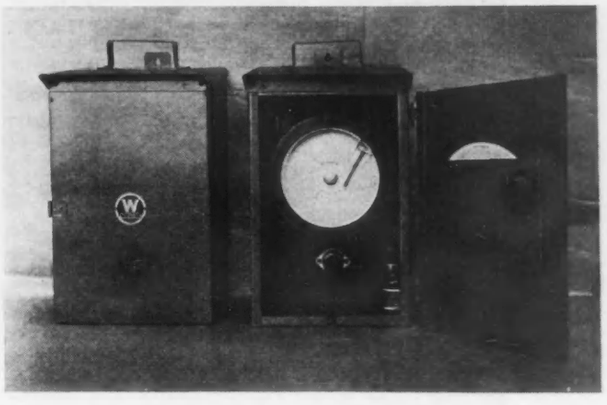

Fig. 14—Type-A graphic voltmeter in steel cabinet for outdoor use, Westinghouse Electric & Manufacturing Company

5. Three-element RB demand meters are now available.

6. Duplex RA totalizers now have motor-operated differentials. This improves the accuracy of operation when only one meter is operating.

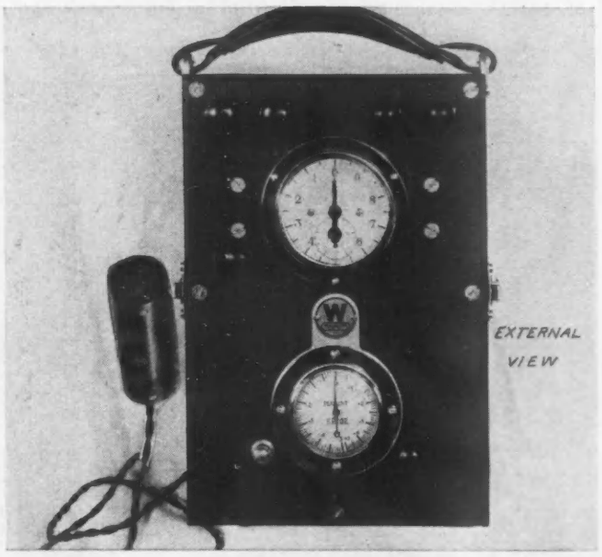

Fig. 15—Portable stroboscopic meter-testing set, external view, Westinghouse Electric & Manufacturing Company

7. A change in the manner of printing RA, RI, and RB charts distinguishes more definitely between the a.m. and p.m. sections of the chart.

8. A new line of contacts has been designed for OB meters. The design of these is such that they will be interchangeable with G-E D-12 and D-13 assemblies.

9. A precision-type OB portable standard is in preparation. Details of this equipment have not yet been received.

10. The type-OC watthour meter is now getting into production. The following improvements in the type OB have been accomplished:

a. Greater carrying capacity.
b. Improved accuracy.
c. Studless covers.
d. Bases and terminals the same size in all capacities.
e. Removable back plate.

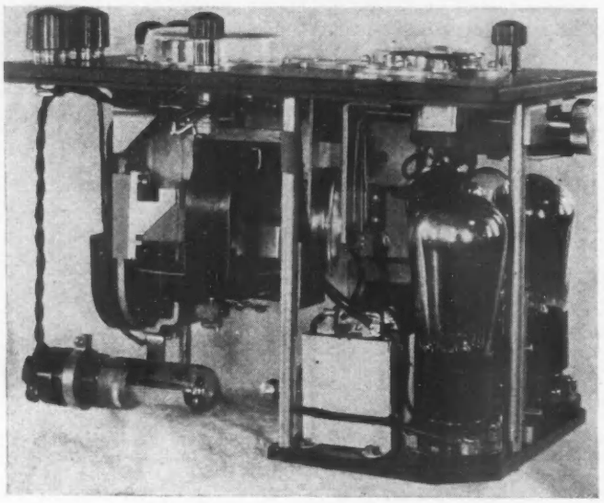

Fig. 16—Portable stroboscopic meter-testing set, internal view, Westinghouse Electric & Manufacturing Company

PACIFIC GAS AND ELECTRIC COMPANY

1. The bureau of tests and inspection has recently developed a load testing device which fills a long-felt want. A steel core having a winding on it is hinged so that it may be clamped around a conductor. Insulated handles are provided so that the operator can manipulate the device without contacting the circuit. The winding is connected to a current-demand indicating instrument which is attached to the transformer. Several ranges are provided, so that various capacities may be covered. Installation of one of these devices on a circuit for 24 hours is readily accomplished, and at the end of that time, the highest reading is indicated on the dial. A more complete description of this device is found on page 612, June, 1931, issue of *Electrical West*.

2. A portable instrument for use in testing watthour meter jewels and pivots has been prepared by E. L. Hughes

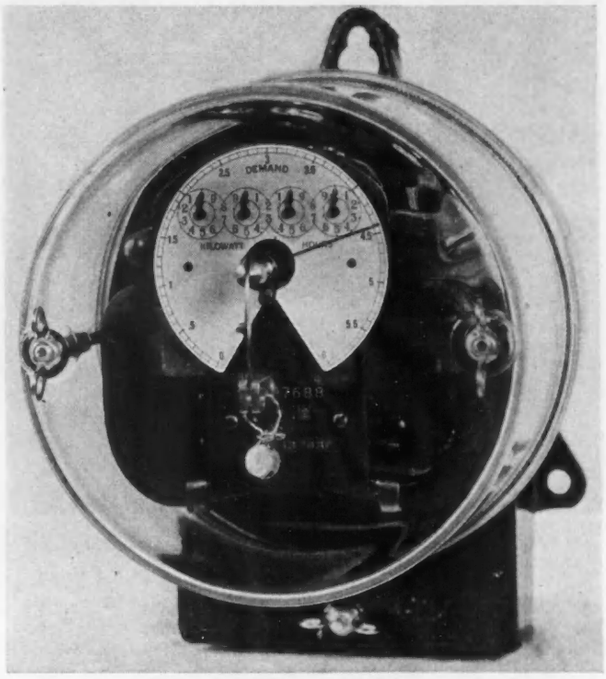

Fig. 17—Type OB demand meter, Westinghouse Electric & Manufacturing Company

of the Pacific Gas and Electric Co. The general appearance is shown in Fig. 18.

A disk weighing about 30 grams is supported on the jeweled bearing. The meter pivot on which the load rests is rotated at a uniform rate. This causes the disk to rotate. It is then possible to determine the friction torque of the bearing.

By means of this device, the friction torque of a new bearing was determined to be slightly over one dyne-centimeter. With defective bearings, the result was found to be considerably over 400 dyne-centimeters in some cases.

This appliance should be of very great assistance in any investigation of bearings, jewel lubrication, etc.

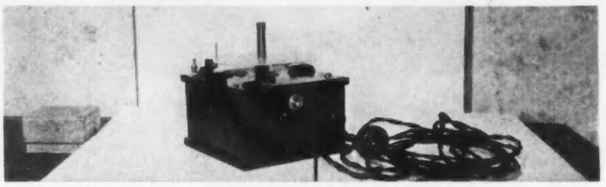

Fig. 18—Portable instrument for testing watthour-meter jewels and pivots, E. L. Hughes of Pacific Gas & Electric Company

OVERHEAD SYSTEMS COMMITTEE REPORTS[1]

*Distribution Transformers**

The subjects treated in this report under distribution transformers are:

1. Elimination of radio interference caused by distribution transformers.

2. Loading of distribution transformers.

3. Standardization of transformer hangers and bushings.

Radio interference caused by distribution transformers can be eliminated by the installation of the proper sized choke coil in series with the primary lead or phase wire and the correct amount of capacity to ground from each secondary line wire.

Loading of distribution transformers has been treated from an economic standpoint with regard to combination loads made up of three-phase motors and single-phase heating, cooking and lighting loads. A set of demand factors has been included, but consideration must be given to local conditions in their use.

A standard for transformer hangers has been proposed. This is only a start and, as it is of nationwide importance, the study should be carried on until a complete standardization is obtained.

The need for a standard aperture in transformer cases so that bushings of different manufacturers will be interchangeable is needed. This is also of national importance and should be carried through until bushing dimensions and case design allow of such interchangeability.

THIS report of the overhead systems committee of the Pacific Coast Electrical Assn. was prepared by the subcommittee on distribution transformers during the year 1931-32.

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[1] D. D. Smalley, Midland Counties Public Service Corporation, chairman. W. E. Row, Southern California Edison Company Ltd., vice-chairman.
Aluminum Company of America: W. Hayes.
California Railroad Commission: C. T. Mess.
Coast Counties Gas & Electric Company: F. D. Beardsley.
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General Electric Company: J. C. Porter, W. C. Smith.
General Electric Supply Corporation: G. A. Hart.
Graybar Company: A. R. Fryklund.
Joint Pole Association: R. E. Hill.
Joint Pole Committee: J. E. McDonald.
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The Pacific Telephone & Telegraph Company: R. C. Barton, D. I. Cone.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, C. F. Dalziel, A. S. Glasgow, C. L. Lawrie, R. H. Taber.
San Joaquin Light & Power Corporation: E. R. Banks, R. V. Hall, H. N. Kalb, C. W. Lightner, H. H. Minor, H. H. Shields, C. C. Wilson.
Southern California Edison Company, Ltd.: C. A. Bennett, J. O. Binney, R. G. Boyles, F. B. Doolittle, R. B. Guilbault, C. E. Heath, J. F. Hodges, F. H. Maver, H. Michener, G. M. Richardson, L. R. Sheppard, E. R. Stauffacher.
The Southern Sierras Power Company: W. B. Loper, E. Y. Porter, A. C. Putman, H. J. Schomberg.
Taper Tube Pole Company: C. DeWitt.
Westinghouse Electric & Manufacturing Company: C. A. Andrews, S. L. Case, C. C. Potts, A. W. Pride.

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* Report of subcommittee on distribution transformers, overhead systems committee, Engineering Section. R. V. Hall, chairman. P. H. Affolter, C. A. Andrews, R. R. Cowles, P. D. Diederich, W. L. Hill, C. L. Lawrie, G. A. Riley, L. B. Smith, W. C. Smith, H. B. Wells.

Loading Distribution Transformers

The proper loading of distribution transformers, although simple to an experienced man, is becoming more of an art and is in itself an economy program as well as an endeavor toward good public relations.

The proper loading is that loading which will give the utility the greatest economy and yet not deter the service to the consumer, as a result either of regulation or of outages due to overload conditions. This is usually considered to be as near full load as is possible to load the transformer, but due to the various types of loads met with in different localities, different demand factors must be applied.

Combination Loading

Most data to date have been compiled for either single-phase or three-phase loads, but very little information on combination loading has been accumulated. The committee has therefore developed a series of charts for the loading of combination banks. These charts are merely a multiplicity of vector diagrams for solving graphically the resultant load on each individual transformer in the bank. In the usual case, the three-phase load is known in terms of the horsepower and the single-phase load is known in terms of kilowatts. However, the horsepower of each motor size is shown on the chart in terms of amperes in each transformer, which is the full-load amperage of the motor divided by the square root of three. The same full-load amperage was used for all power factors, which perhaps is not quite correct; for greater accuracy the amperage at the known power factor should be used.

The next step is to determine the division of single-phase load in each respective transformer. It will always be the same on any bank connected star-delta. That is, two-thirds of the total single-phase load will be supplied by the transformer to which the single-phase load is directly connected and one-third by the other two transformers. This division of load will not be changed, regardless of the use of transformers of a different size or impedance.

The power factor of each load must be known or assumed. Three-phase motors, operating at around full load, usually have a power factor of about 85 per cent. Charts were made up for four different power factors so as to cover the entire field and to give those not familiar with this type of loading a fair conception of what is happening in a bank of transformers thus loaded.

The maximum loading condition for the transformer to which the single-phase load is directly connected is when both single-phase and three-phase loads are of the same power factors, regardless of whether they may be 80 or 100 per cent, as currents of the same phase relation will be a direct addition. As the power factor on the three-phase load is reduced or becomes poorer, this tends to reduce the load on this transformer, as long as the single-phase load remains at 100 per cent power factor, due to the vectorial addition of these two currents.

The other two transformers load up equally, provided that the single-phase and the three-phase loads are both 100 per cent power factor. For any other power factor they will load up unequally, and the one which will load up first depends on two things: the rotation and whether leading or lagging power factor.

For anticlockwise rotation and lagging power factor or clockwise rotation and leading power factor, transformer No. 2 will be the one that will load up first. For clockwise rotation and lagging power factor or anticlockwise rotation and leading power factor, transformer No. 3 will load up first. Therefore, if two transformers of equal kva. capacity are installed in conjunction with a larger transformer, it is only

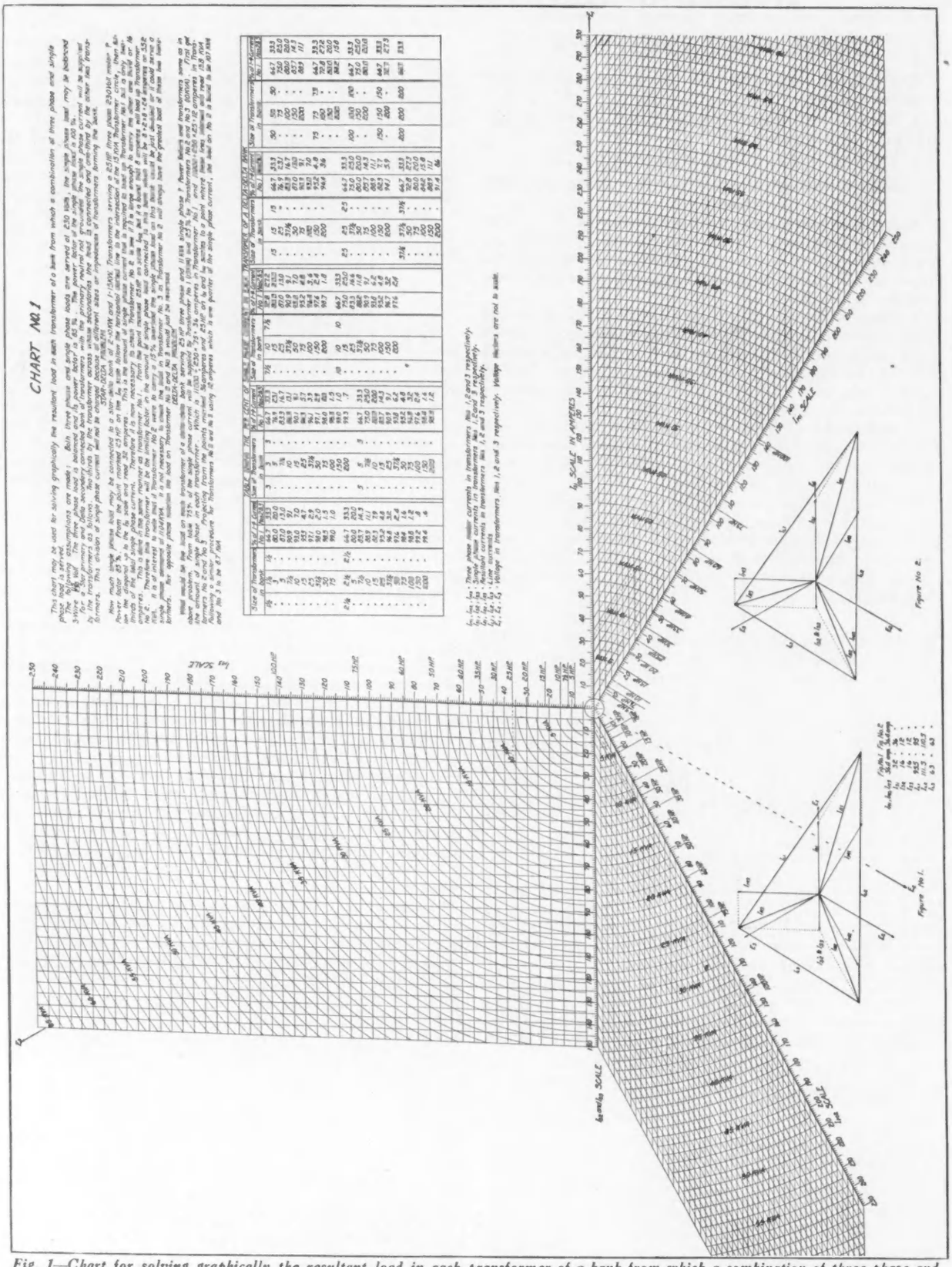


Fig. 1—Chart for solving graphically the resultant load in each transformer of a bank from which a combination of three-phase and single-phase load is served

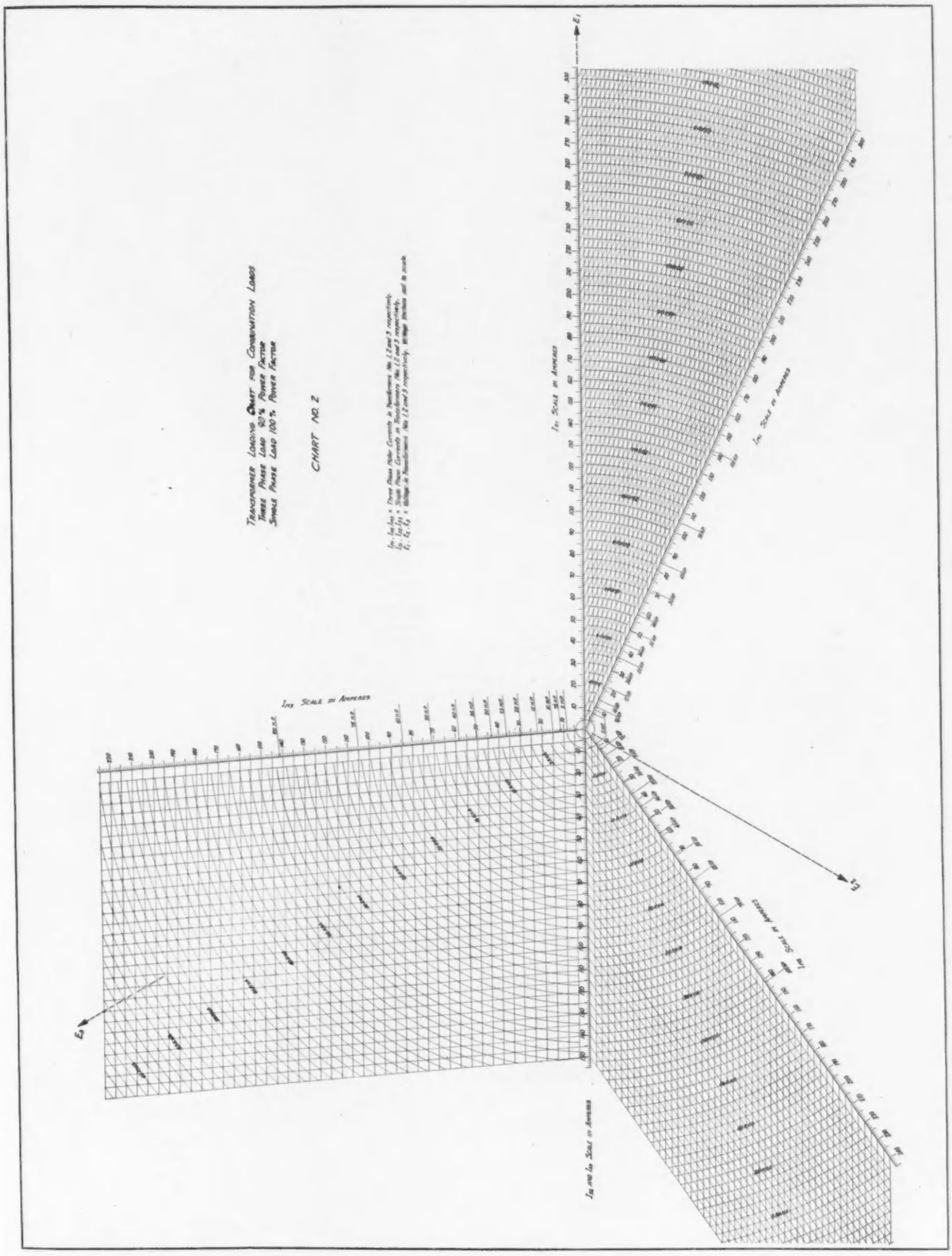


Fig. 2—Transformer loading chart for combination loads, three-phase 90 per cent, single-phase 100 per cent power factor

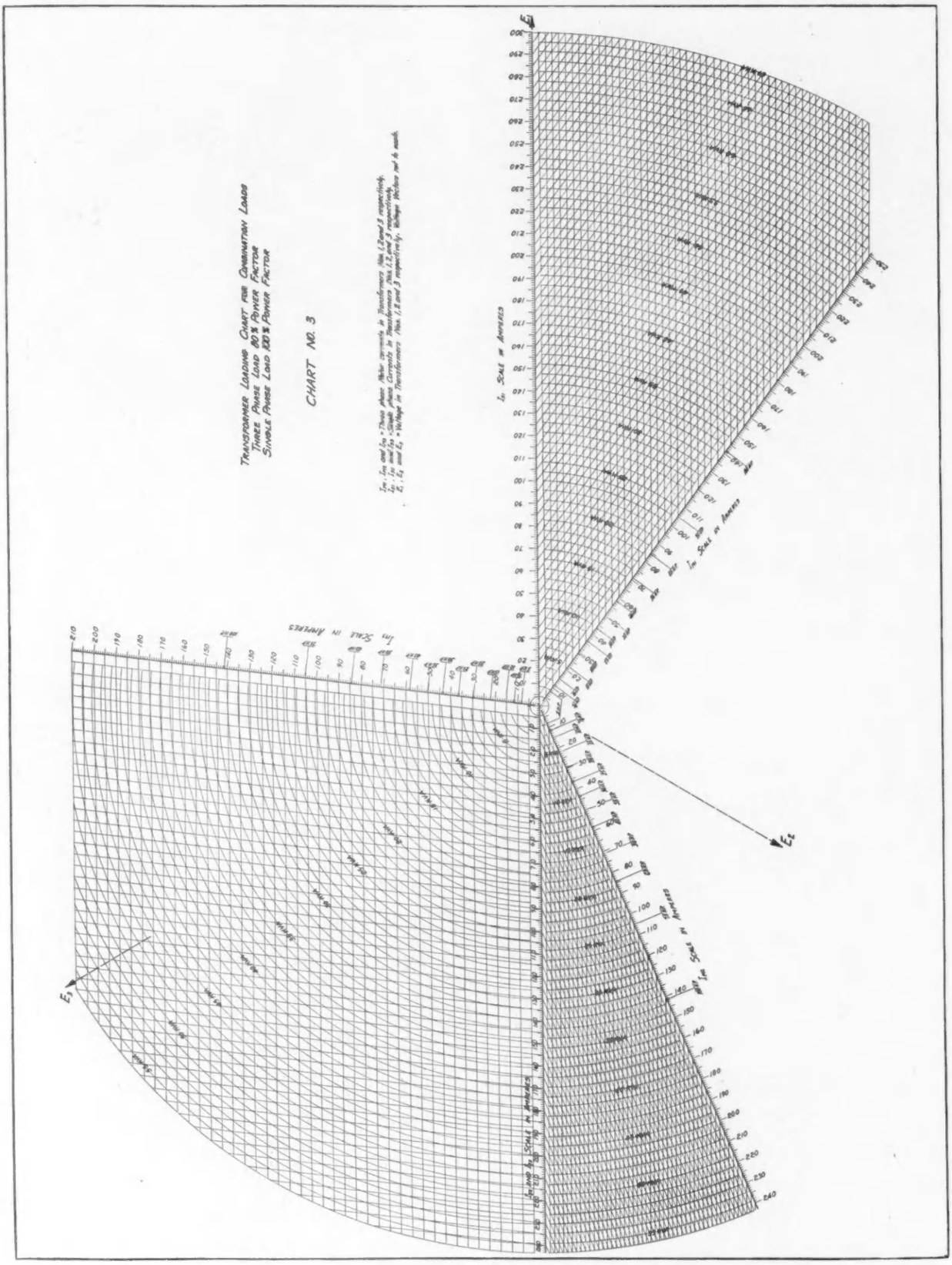


Fig. 3—Transformer loading chart for combination loads, three-phase 80 per cent, single-phase 100 per cent power factor

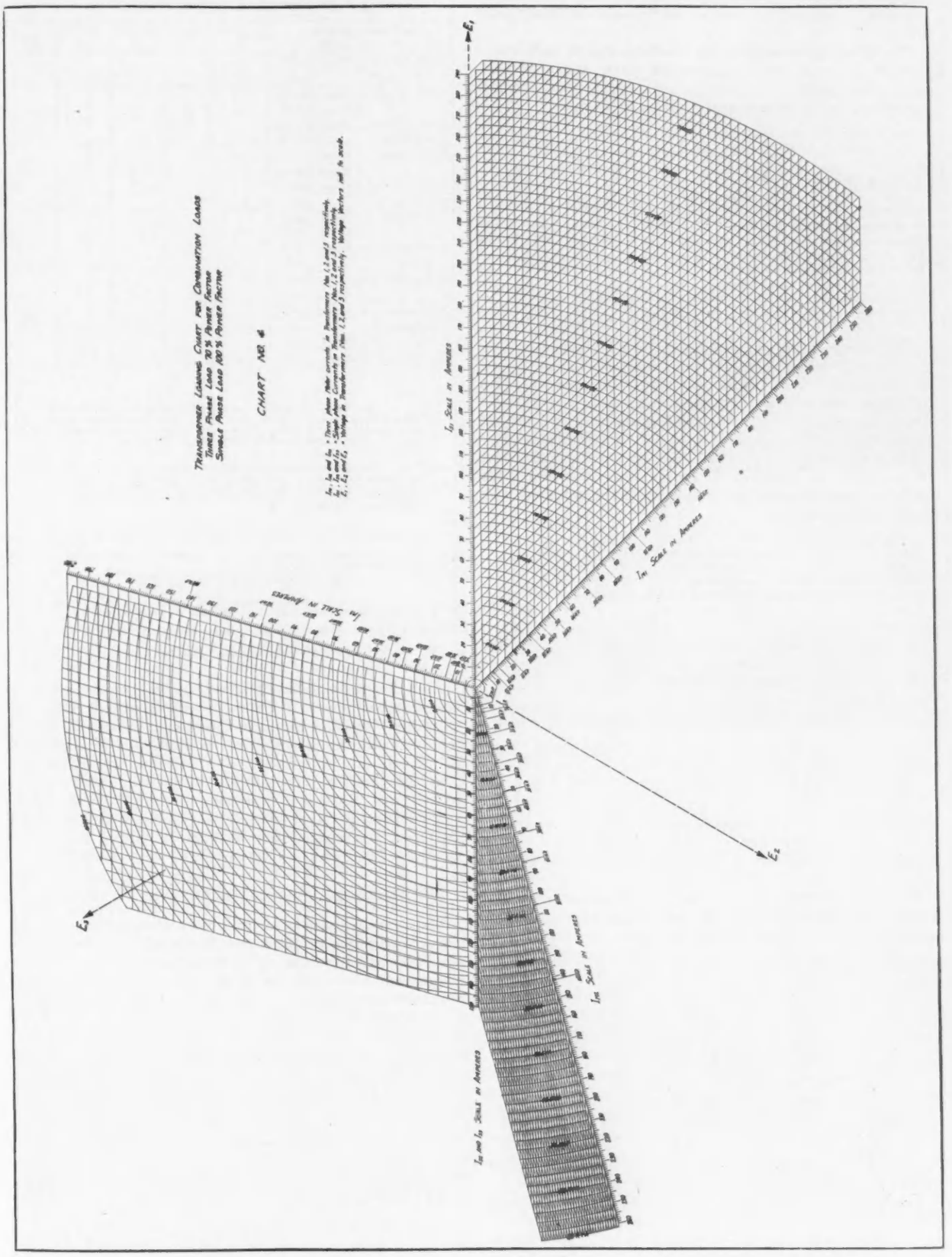


Fig. 4—Transformer loading chart for combination loads, three-phase 70 per cent, single-phase 100 per cent power factor

necessary to check the loading on the one that will load up the first, depending on rotation and power factor as given above.

The following table gives the resultant load on each transformer due to a 35-hp. three-phase motor and a 34.5-kw. single-phase load served from a combination bank. Single-phase load is 100 per cent power factor in all cases.

Three-phase load	Rotation	Transformer Numbers 1 Load in Kva.	2	3
100 per cent	Clockwise or anticlockwise	34.5	19.9	19.9
90 per cent lagging	Anticlockwise	33.8	21.9	17.0
90 per cent leading	Clockwise	33.8	21.9	17.0
85 per cent lagging	Anticlockwise	33.4	22.4	16.1
85 per cent leading	Clockwise	33.4	22.4	16.1
80 per cent lagging	Anticlockwise	32.9	22.5	15.3
80 per cent leading	Clockwise	32.9	22.5	15.3
70 per cent lagging	Anticlockwise	32.0	22.6	13.8
70 per cent leading	Clockwise	32.0	22.6	13.8

The subcommittee on loading of transformers last year gave quite a complete study to the most economical loading of distribution transformers. The study presented was for a congested area with a fairly good load factor and does not hold true for individual loads, nor for any class of load with a poor load factor, such as ranges and water heaters, etc.

From actual field test on the San Joaquin Light & Power Corp. system, we measured the consumption of several range loads and several range and water heater installations with the following results:

9-kw. range and lights, consumption 8.25 kw.-hr. per day.
Core loss on 5-kva. transformer, 1.152 kw.-hr. per day.
Copper loss on 5-kva. transformer, 0.164 kw.-hr. per day.
Total losses on 5-kva. transformer, 1.316 kw.-hr. per day.
Loss in per cent of consumption, 15.93.

For a 7.8-kw. range, 5-kw. water heater and lights the consumption was 17.14 kw.-hr. per day and losses were as follows on three different sizes of transformers:

Size of transformers kva.	Core loss per day kw.-hr.	Copper loss per day kw.-hr.	Total losses per day kw.-hr.	Losses in per cent of consumption
5	1.152	0.488	1.600	9.33
7½	1.584	0.303	1.887	11.00
10	1.920	0.198	2.118	12.36

For a total of 60 kw. in connected load of ranges and water heaters the consumption per day was 45.92 kw.-hr. and the losses were computed as follows for three different sizes of transformers:

Size of transformer kva.	Core loss per day kw.-hr.	Copper loss per day kw.-hr.	Total losses per day kw.-hr.	Loss in per cent per day
10	1.920	0.572	2.492	5.4
15	2.472	0.466	2.938	6.4
25	3.840	0.226	4.066	8.9

From a study made on one of our substation feeders the following results were obtained:

For 123 water heaters and 214 ranges and 388 lighting consumers the kilowatt-hour consumption for 30 days was 91,137 kw.-hr., the core loss was found to be 13,668 kw.-hr., copper loss 1,555 kw.-hr., or a total of 15,222 kw.-hr. Therefore the total transformer losses alone give a loss of 16.7 per cent of the consumption for the month.

These tests prove conclusively that the smaller the transformer that will adequately serve this type of load, the more economical it is. This will be true even though it is considerably overloaded for short intervals, provided it does not interfere with the service from the standpoint of regulation, as the core loss runs from five to ten times the copper loss. The high core loss ratio on this feeder investigation is due to individual lighting installations where a 2½-kva. 11,500-volt transformer is installed to serve these individual lighting loads. On some of these installations during the summer months the core loss is 450 per cent of the consumption.

TRANSFORMER LOADING CHART

Use loads given on one line only.	Transformer Capacity in K.V.A. 5	7½	10	15	25
1-3 K.W. Water H. 1-Range Lights	X				
1-5 K.W. Water H. Lights					
1-5 K.W. Water H. 1-Range Lights					
3-Ranges Lights		X			
1-5 K.W. Water H. 2-Ranges Lights					
2-5 K.W. Water H. Lights					
2-5 K.W. Water H. 2-Ranges Lights					
5-Ranges Lights			X		
2-5 K.W. Water H. 3-Ranges Lights					
3-5 K.W. Water H. Lights					
2-5 K.W. Water H. 4-Ranges Lights					
10-Ranges Lights				X	
3-5 K.W. Water H. 4-Ranges Lights					
5-5 K.W. Water H. Lights					
4-5 K.W. Water H. 10-Ranges Lights					
20-Ranges Lights					
5-5 K.W. Water H. 8-Ranges Lights					X
10-5 K.W. Water H. Lights					
6-5 K.W. Water H. 6-Ranges Lights					
7-5 K.W. Water H. 4-Ranges Lights					

This table must be used with discretion and is for ordinary residences, no attempt is made here to set up a transformer size for commercial types of loads. These must be given special consideration and are very nearly in direct proportion to the amount of business transacted.

Ten ordinary residence lighting consumers may be served in conjunction with the loads given in this table for transformers up to and including 10 K.V.A. Transformers above 10 K.V.A., twenty lighting consumers are permissable without an increase in transformer capacity.

Demand factor for air heat with not more than three heaters 75% of the connected load. For more than three heaters 50% of the connected load.

For all loads of greater capacity than those given on this chart use the following demand factors.
8 consumers 100 to 150 K.W. use 50 per cent.
12 consumers 150 to 200 K.W. use 25 per cent.

The size of the range makes little difference as the use is about the same for a 3 K.W. as for a 11.5 K.W. range for domestic use.

Fig. 5—Transformer loading chart

Standardization of Transformer Hangers

The standardization of transformer hangers was first taken up by the Pacific Coast Electrical Assn. in 1924-25 under the subcommittee on distribution transformer standardization. The committee at that time felt that they should not make any recommendations that would hamper one manufacturer and be beneficial to another in the design of the transformer itself.

However, the committee at that time made four recommendations in regard to standardizations of transformer hangers. The committee takes the liberty of reprinting their recomendations.

Recommendations of 1924-25 Committee

The definite recommendations this committee has to make, which are concurred in by most of the member companies, especially those along the Pacific Coast, are: (1) That the minimum length of transformer hanger be 32 in.; (2) That for transformers of 15 kva. and larger, the hanger should not extend below the bottom of the transformer case; (3) That all transformers should be designed to mount on the hangers so that the top of the case will be 4½ in. below the top of the hanger iron support; (4) That the hanger iron top should be designed to fit over a 4-in. crossarm and have a lip on the hook extending down 2 in. These dimensions are shown in Fig. 6. We would recommend that the various manufacturers get together and standardize on the dimensions (A) and (B) and diameters of bolts (C) for certain sizes of transformers. This would probably require two, or at the most four, hangers.

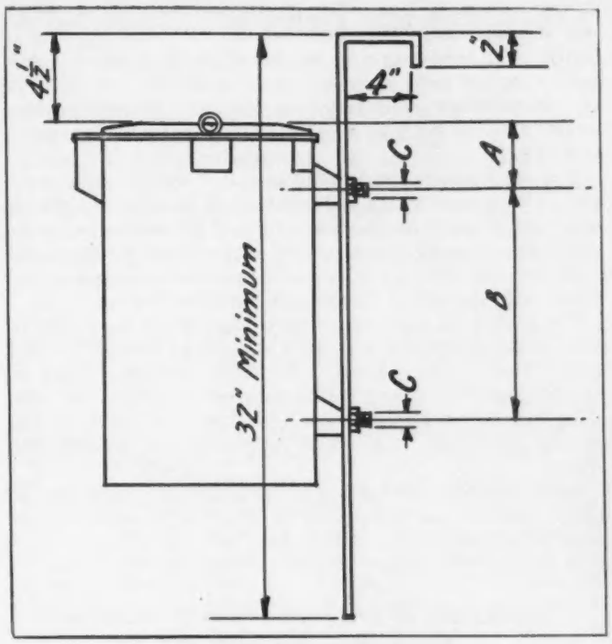


Fig. 6—Proposed standard hanger, 1924-1925 committee

The committee at this time felt that we should do nothing to hamper the inherent design of the transformers themselves but that a standardization of hangers and bushings was well worth considering.

For a manufacturer to go ahead and standardize his own product on such simple things as hangers and bushings is not enough, as in such standardization there will be just as many different types as there are manufacturers. The standardization must be carried through to a complete standardization, in much the same way as the gage of a railroad. Then and then only, when there is complete agreement, so that one manufacturer's hanger or bushing will fit the transformer of any other, will there be any real good derived from standardization, or any such economies effected as we have hoped for.

These economies are perhaps hidden to the manufacturer, as he sends out a set of hangers with each transformer, and it is an easy process for him, as the order goes out for the same number of transformers, hangers, etc. Of course that particular type of bushing to fit that particular type of case may be readily obtained, but suppose someone was to bring in on the floor a case manufactured some fifteen years ago—and see what would happen. This case would perhaps remain on the floor an extra day while some one looked up the proper bushings and hangers. This is what each operating company has to face, only the condition is far more aggravated, as they have several manufacturers' products to deal with, all at a variance.

Fig. 7—The eight transformers here shown are all of the same voltage class (6,900-volt) and the same kva. rating (3-kva.) and require seven different hangers and five different sized bushings. The same conditions exist in other sizes and it is getting worse each year due to new designs. It is time for the electrical industry to call a halt to this wanton waste that can so easily be taken care of by simple standardization

Cost of Lack of Standardization

Let us go into this cost briefly. First, there are at least 600 cities in the United States with population over 20,000 as per the 1930 census. Assume that there is only one warehouse per city that sends out transformers which will require, on an average, two man-hours per day, 300 days per year, to look up the proper hangers. This requires 360,000 man-hours or 45,000 days at $6 per day, which gives $270,000 per year, which is a direct operating charge due to lack of complete standardization. There is still another charge which I have not attempted to show and that is a case, which happens occasionally, where a line crew will get out with the wrong

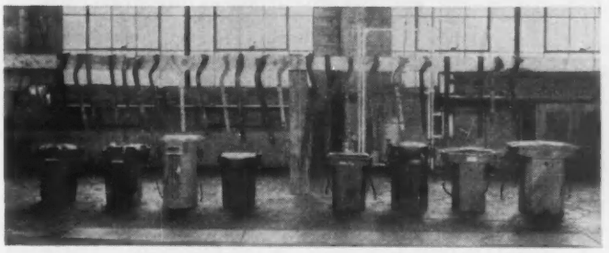


Fig. 8—Same as Fig. 7, front view

hangers and have to exchange them, perhaps holding up the whole crew while this is being done. You will no doubt say that this is carelessness on the part of the man picking out the hangers, which is only too true, but perhaps he measured

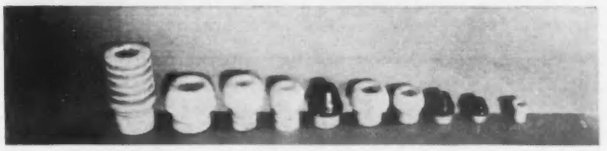


Fig. 9—Showing ten different types of 2,300-volt bushings that must be kept in stock to fit the present day transformers, whereas one of the right design would be adequate

the spacing of the holes correctly but overlooked the fact that the transformer case required ⅝-in. bolts and the hangers were only punched for ½-in. bolts; so, regardless of whether or not the bolts were carried on the truck, it would be impossible to hang the transformer until the hangers were exchanged.

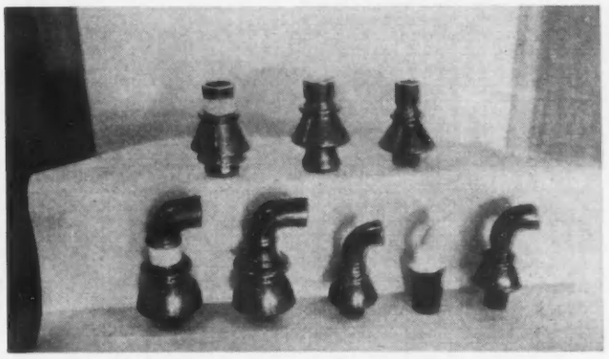


Fig. 10—Showing eight different types of 6,900-volt bushings necessary to fit different transformers carried in stock. A complete standardization of the size of neck of the bushing is all that is necessary or all that we can hope for, but with this accomplished, one bushing would do for all transformers of that voltage class up to a size of 50-kva. at least

To point out the real necessity of a complete standardization we submit Figs. 7 to 11.

A questionnaire was mailed out to all members of the committee and to some twenty operating men in direct contact with operating conditions. All have agreed that we should have a complete standardization. Eighteen have agreed that two hangers are ample to cover the field of transformers that will be hung on hangers. All have agreed that transformers above 100-kva. capacity need not have hangers.

Fig. 11—Showing six different types of 11,500-volt bushings. Some of these bushings also fit the 6,900-volt class. It may be an economical step to make these bushings interchangeable on 6,900-volt transformers due to the small difference in voltage

Fig. 12 is submitted as a standard hanger.

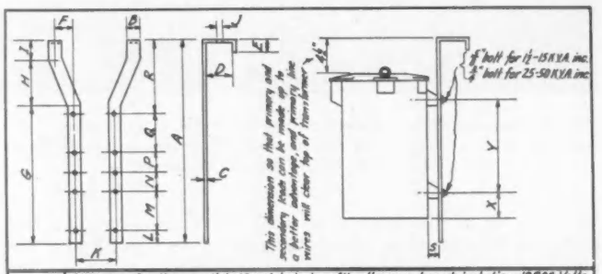
Suppressors for Elimination of Radio Interference Caused by Distribution Transformers

The use of suppressors on distribution transformers causing radio interference has been successful on all installations on our system to date. Within the past year about twelve sets of suppressors were installed and have functioned perfectly. The condenser unit has been left off on some installations, but is quite essential where a radio is operated on the transformer secondary. A set of chokes inspected recently, seem to have weathered the past winter satisfactorily.

The suppressors are usually installed by the radio crew and a check made with a radio test set at the time of installation. In all instances the test set failed to pick up any noise under the primary line after the chokes were installed, the radio test set used being an eight-tube battery-operated receiver with sensitivity comparable with the average radio.

The chokes or suppressors have been found applicable to other noisy equipment and work equally as well when used within their power rating. We have one pair in use to prevent radio noise, originating on a transmission line, from being distributed in one of the small towns we serve, by our private telephone line which parallels the transmission circuit.

Since the wire size used in constructing the choke coils is small and the coil completely inclosed in a bakelite case with no opportunity to radiate heat, the use of the present type of choke is confined to small transformers.



	Dimensions for Hangers 1½ to 15 K.V.A. inclusive. All voltages up to and including 13,200 Volts.																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S
Proposed	31	2	⅞	4	1⅛	3	22½	7	2	⅝	6	1½	7	3	3	7	9⅛	1⅛
Reply No1	28½	2	⅞	4	1⅛	3⅜	21	5	2½	⅝	6	2	2⅞	4⅛	*2½	5⅛	10⅛	
" No2	31	2	⅞	4	1⅛	3	22½	7	2	⅝	6	1½	7	3	3	7	9⅛	1⅛
" No3	Agreeable with proposed Standard																	
" No4	Agreeable with proposed Standard.																	
" No5	Agreeable with proposed Standard.																	
" No6	Agreeable with proposed Standard.																	
	Dimensions for Hangers 25 to 50 K.V.A inclusive. All voltages up to and including 13,200 Volts.																	
Proposed	43	2	½	4	2	4	34½	7	2	⅝	8	1½	8	8	8	8	9⅛	1⅛
Reply No1	37	2	½	4	1⅛	4⅜	28½	6	2½	⅝	8½	2	2½	5⅛	*2½	5⅛	12⅛	
" No2	43	2	⅞	4	2	4	34½	7	2	⅝	8	1½	8	8	8	8	9⅛	1⅛
" No3	Agreeable with proposed Standard.																	
" No4	Agreeable with proposed Standard.																	
" No5	Agreeable with proposed Standard.																	
" No6	Agreeable with proposed Standard.																	

		Transformer Capacity in K.V.A.										
		1½	2½	3	5	7½	10	15	25	37½	50	75	100
Proposed	X	Variable with minimum of 2 inches.											
	Y	7	7	7	10	10	10	13	16	24	24	32	32
Reply No1	X												
	Y	10⅛	10⅛	10⅛	11⅛	11⅛	17⅛	17⅛	24	29⅛	29⅛	29⅛	29⅛
Reply No2	X	Variable with minimum of 2 inches.										Leave to Mfgr.	
	Y	7	7	7	10	10	10	13	16	24	24	Leave to Mfgr.	
Reply No3	X												
	Y	Agreeable with proposed Standard.											
Reply No4	X												
	Y	Agreeable with proposed Standard.											
Reply No5	X												
	Y	Agreeable with proposed Standard.											
Reply No6	X												
	Y	Agreeable with proposed Standard.											

*2 Extra holes 2⅛ and 2½.
0 - 1 Extra hole 7/8.

Fig. 12—Standard hanger

Elimination of Radio Interference Caused by Distribution Transformers

The following is an extract from a radio report on the San Joaquin Light & Power Corp. system:

The transformers at this location had been condemned at the warehouse on account of radio noise. They were installed at this location to serve a pump only. When installed they were equipped with radio suppressors and condensers. The transformers are 7½ kva. 6,900-230/115. Since there was no lighting load here and the possibility of a radio set ever being used on the secondaries was improbable, the condensers were removed. This did not affect the action of the suppressors but did permit the noise to flow in the secondaries; that is, with the condensers off, our test set picked up noise under the secondaries where it had been free from any noise with the condensers on. Various combinations of suppressors were installed and removed and the effect on the test set noted. All three transformers were found to be noisy and no combination of suppressors stopped the noise until there was one in each high-voltage lead.

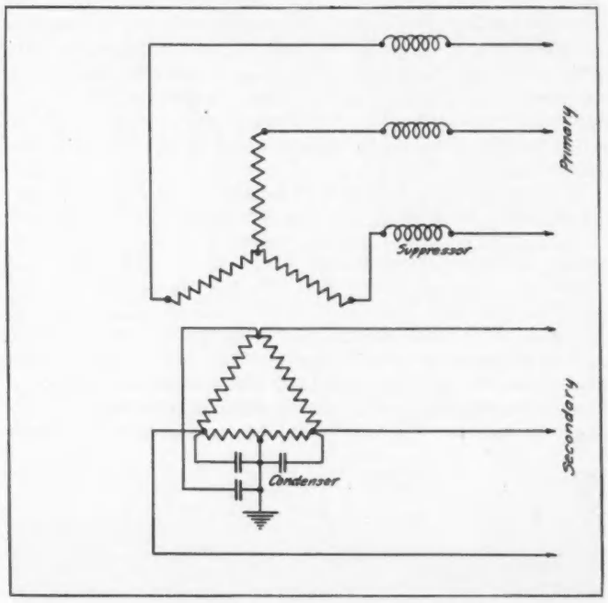


Fig. 13—Schematic diagram for application of radio suppressors

As a means of comparison, KFI was received satisfactorily under the 11-kv. line with the suppressors installed. When any or all of the suppressors were removed, reception was impossible. The suppressors effectively prevent the flow of radio noise back into the 11-kv. line from the transformers.

*Development in Fog-Type Insulators**

Investigations of the insulator committee reveal the fact that considerable work has been done toward solving the insulator troubles which are due to fogs. There are several types of insulators on the market for which excellent results are claimed, but the trial period has not been long enough to state positively that they are cure-alls. One company claims a perfect record with fog-type insulators over a 2½-year period, but the committee does not feel that 2½ years are sufficient to base any claims on.

IN analyzing this subject, the committee finds that all of the utilities operating in territory contiguous to the ocean front or on bays are having insulator troubles. All of the troubles are similar in nature, and therefore can be considered as common. The troubles are primarily flashovers, particularly on the higher-voltage circuits such as 60-kv., 100-kv., and 220-kv. All of the troubles have caused major interruptions; therefore, the utilities are making every effort to reduce the troubles and, if possible, to eliminate them entirely. To this end they have called the manufacturer in to help solve the problem. This is nothing new but the trouble has been accumulating over a period of at least ten years. It has only been in recent years, however, that any direct results have been attained.

In studying the cause for the troubles, we find that the fog is in reality a secondary cause and that pollution or fouling of the porcelain is the primary cause. Pollution removed from the insulators that have given trouble has been analyzed, yielding as many as ten different materials, the most of which are fair conductors. The most prominent material found is salt in the form of crystals formed by the evaporation of sea spray in a dry wind and carried inland. Meteorological data indicate that such crystals are one of the main constituents of the permanent impurity of the atmosphere. Other important materials found on insulators are iron and aluminum oxide. These materials on an insulator, when subject to a dense atmosphere such as fog, reduce the actual flashover value of an insulator to such an extent that flashover occurs. In laboratory tests the flashover value of fouled or polluted insulators in a dense atmosphere, such as a fog, has actually been reduced to less than 30 per cent of the normal rating. Of all the pollution materials found on fouled insulators, metallic dust and cement dust appear to be the most harmful, tests showing that they reduce flashover values to 15 per cent of the nominal value.

It appears that the solution to the problem is a self-cleaning insulator. At the present time there is no such insulator available. In the development of insulators to overcome the fog troubles, the manufacturers have put out various shapes and types. One design has attempted to apply Sinding-Larsons' fundamental idea by providing high-resistance paths over the insulator surface to ground, the heating action of the leakage current tending to warm the insulator surface and thus to prevent moisture condensation thereon; others (Barford Lapp) have proposed a design with practically uniform leakage resistance path, so that the voltage drop along the leakage surface is uniform, thus preventing partial surface flashovers, while the normal I^2R heat loss tends to dry the surface, thus tending to reduce the leakage current and preventing complete flashover under fog conditions. The first design has not proved altogether satisfactory; the second is now undergoing field trial.

One utility now has some 50,000 insulators installed, some of which have been up three years, during which operation has been perfect. These are installed in a twin-circuit 220-kv. line in an area which has severe fog conditions. Prior to the installation of these insulators, standard types were used and in order to operate it was necessary to clean insulators at least three times a year. Following the installation of the fog-type units, skepticism prevailed among the operators who continued to wipe insulators every sixty days for six months; they then finally decided to try them without wiping. It has been 2½ years since these units have been cleaned and results have been excellent to date. From the reports received, it appears that perhaps the solution to the problem has been found.

Two other utilities report may years of satisfactory service in fog territory with a unit that is practically flat, having no petticoats or corrugations whatever. These units are being used on both 60-kv. and 110-kv. lines and the utilities feel that the remarkable service record is due to the unit not having corners in which dirt might accumulate. The utility that is using the Barford Lapp design did not try any of the smooth types above mentioned, so could not report them.

The fog trouble is not limited to higher voltages, most of the utilities reporting that secondary lines are also involved. Several of the utilities are experimenting at this time, using the Barford Lapp design of pin-type units. The trial period has been too short to give any definite conclusions, but so far operation has been satisfactory and shows improvement over what it was with the ordinary types of insulators.

It has been suggested by several of the utilities that the committee endeavor to set up tables recommending insulators for fog service with respect to voltage. At the present time this is not possible, for the reason that all work under way is in the form of an experiment and results are not conclusive. It is hoped that at a future day such a recommendation may be available.

The committee believes that the utilities are approaching an answer to this problem and the next few years will determine what the answer is.

The committee recommends still further cooperation between the utilities and the manufacturers to the end that we may get the best possible answer to our problem at the least cost, for after all we are confronted with giving the best possible service for the least cost, and having to wipe insulators is an expensive piece of work.

Radio Interference From Insulators

The committee has endeavored to get information on this subject that would be of help to all of the utilities, but with little success. Only one utility replied.

The committee looked up all available data and found such a divison of opinion on this subject that they feel the time is not right to make a report.

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*Grounding**

The subcommittee on grounding has endeavored to follow the suggestions of last year's committee and while not a great deal of experimental data has been obtained, some progress has been made.

The subject has been divided into five groups:

1. Dependability of grounded connections.

2. Areas where high resistance ground values are encountered.

3. Circuit classification.

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* Report prepared by N. P. Carlsen, Jr., for the subcommittee on insulators, overhead systems committee, Engineering Section. N. P. Carlsen, Jr., chairman. P. H. Affolter, K. B. Ayres, A. M. Bohnert, S. L. Case, F. B. Doolittle, L. C. Edwards, C. E. Heath, H. N. Kalb, J. B. Madden, E. R. Northmore, W. E. Row, E. M. Wright.

* Report of the subcommittee on grounding, overhead systems committee, Engineering Section. J. F. Hodges, chairman. D. I. Cone, A. S. Glasgow, J. W. Finchley, C. E. Ingalls, C. B. Judson, E. A. McGinly, F. H. Maver, C. T. Mess, E. Y. Porter, E. R. Stauffacher, J. O. Tobey, C. E. Young.

4. Multiplicity of ground connections.

5. Types of ground electrodes.

These groups were divided among several committee members.

In the preparation of these reports dealing in general with the same subject some duplication has necessarily occurred.

*The Dependability of Ground Connections—A Subdivisional Topic of Grounding**

THE installation and maintenance of low resistance grounds of electrical equipment and wiring is nearly always a matter of considerable importance and often it is one of some little difficulty of accomplishment.

There may be some little difficulty in the installation from a mechanical standpoint. This involves the cleanness and accessibility of the pipes, type of clamp, and the kind of surface protection used to protect the connection from corrosion. In many locations the real trouble is found in the absence of low-resistance soil and suitable underground electrodes. The methods used to overcome these difficulties are properly considered under the head of grounding.

In this study no consideration will be given to the mechanical excellence of grounding clamps as to strength, convenience, etc. It is taken for granted that failures due to mechanical injuries, wear, and stress are a matter of location and accident and can, therefore, be more properly considered from a statistical standpoint. It is believed, however, that this factor is almost negligible as compared to the assaults of the chemical elements of the air and soil in producing corrosion.

Probably the subject of corrosion in its various forms is less understood than is any other major engineering problem. It is certain that experience has shown that the pipe clamp is no less immune from its attack than are other metallic engineering structures. The severity of this attack and the importance of their dependability are sufficient to justify a careful study of our subject.

Before attempting any experimental investigation, it is well at the outset to consider carefully from a theoretical standpoint all the factors that may appear to have a bearing.

* Prepared by C. B. Judson of the Los Angeles Gas and Electric Corp.

Let us now examine the problem from our present vantage point to make a more or less intelligent guess as to what results we may expect and incidentally to devise means either

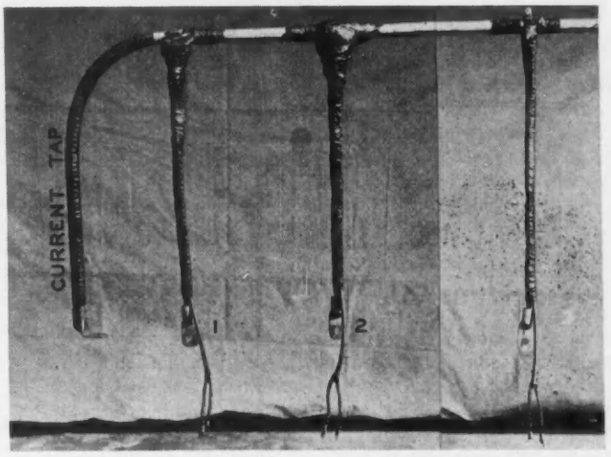

Fig. 2—Position 1—"E" clamp using No. 1 stranded copper wire. Clamp left bare at point of contact with pipe (see detail A). Initial resistance 0.0000093 ohms. Position 2—"E" clamp using No. 1 stranded copper wire. Entire clamp wrapped with canvas osnaberg and covered with tar (see detail A). Initial resistance 0.0000083 ohms. Position 3—A-B-C clamp with copper U-bolt bare (see detail C). Initial resistance, 0.0000067 ohms.

to prove or disprove them. The question is:: What are the factors in the corrosion of grounding clamps which affect their dependability?

In the absence of surface protection, corrosion will attack to a greater or lesser degree either one or both the grounding clamp and the pipe. This rate of attack may be accelerated by the galvanic potentials between dissimilar metals. If so, there will be a choice in the metals to be used. Corrosion may be increased by molecular strains set up in the metal by compression or tension. If so, good designing calls for an increase in the surfaces in contact and the thickness of metal in tension. In a given clamp, are all the parts properly proportioned like "the wonderful one horse shay" so that they will last equally long? Does rust lessen the dependability of grounding clamps, chiefly by the formation of rust between the surfaces in contact, or by the destruction

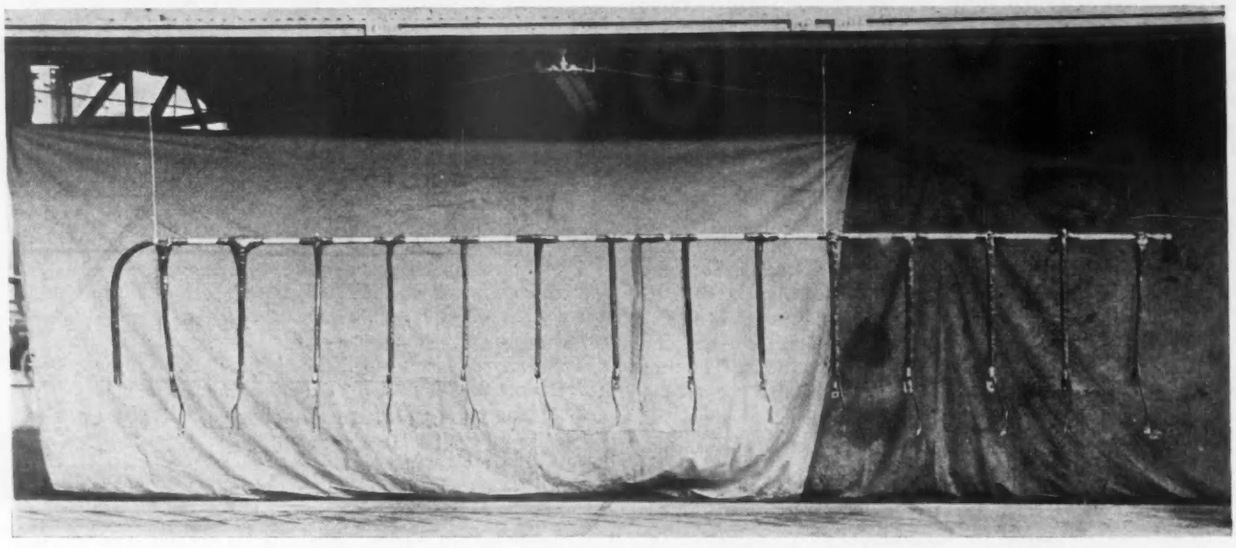

Fig. 1—Assemblage of fourteen grounding clamps on 1-in. galvanized iron pipe. One was prepared for soil and the others for atmospheric exposure. These are shown in more detail in other illustra tions.

of the body of the clamp? To what extent may the surface insulation by paints, dips, etc. be relied upon to prevent corrosion? In locations where salt is used to impregnate high resistance soils, should some special care be observed in the installation of grounding clamps as to size, weight or insulation? These are some of the theoretical considerations that may serve as a starting point for an experimental test. Other questions may arise and other factors be discovered in the course of the study.

In pursuance of the test, a number of grounding clamps of special design and standard manufacture were connected to

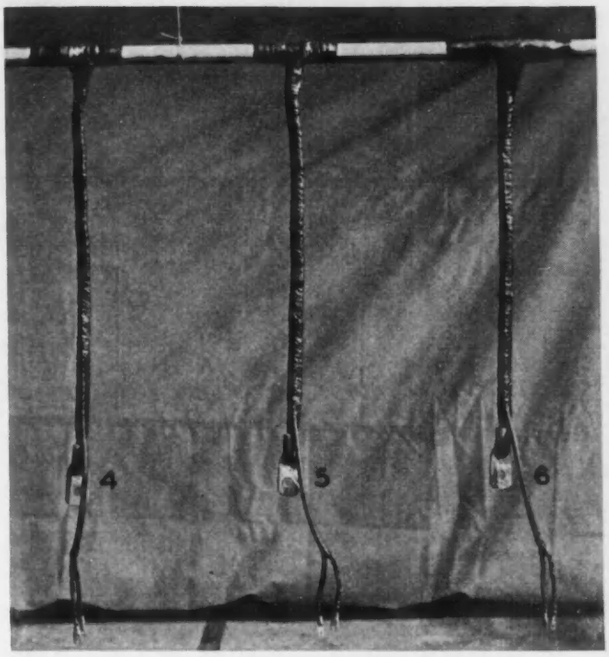

Fig. 3—Position 4—perforated copper strap bare (see detail B). Initial resistance, 0.0000166 ohms. Position 5—perforated copper strap covered with No. 127 red lacquer (see detail B). Initial resistance, 0.0000243 ohms. Position 6—perforated copper strap covered with pitch (130 deg. melting point) (see detail B). Initial resistance, 0.0000139 ohms

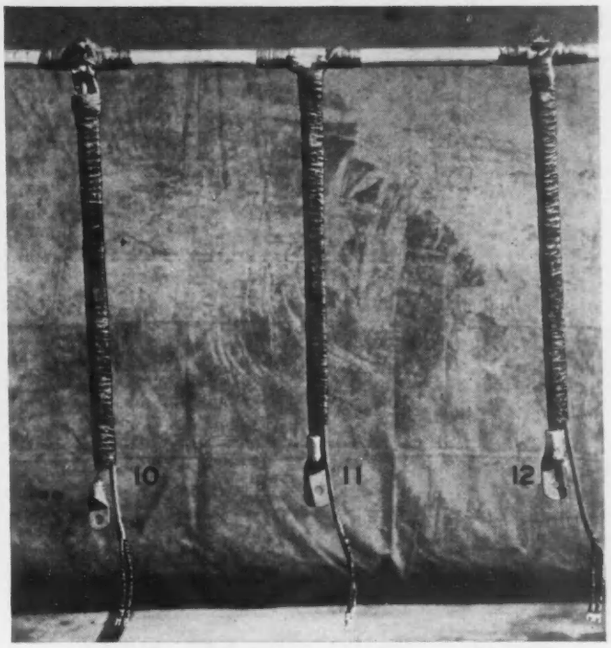

Fig. 5—Position 10—T.B. patented clamp bare, (see detail E). Initial resistance, 0.0000028 ohms. Position 11—diamond E pipe connector bare (see detail D). Initial resistance, 0.0000762 ohms. Position 12—"J. P. Brown, L. A. Gas" connector bare (see detail F). Initial resistance, 0.0000797 ohms

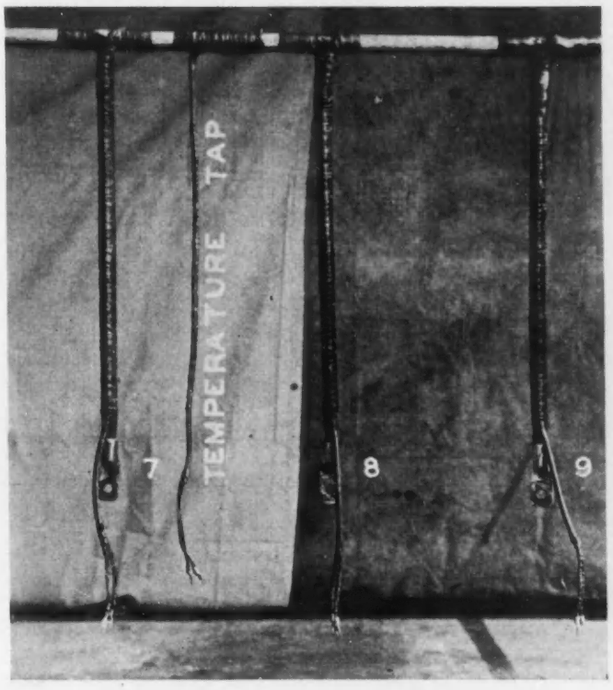

Fig. 4—Position 7—perforated galvanized iron strap bare (see detail B). Initial resistance, 0.0000416 ohms. Position 8—perforated galvanized iron strap covered with No. 127 red lacquer (see detail B). Initial resistance, 0.0000673 ohms. Position 9—same as No. 8. Covered with pitch (130 deg. melting point). (see detail D). Initial resistance, 0.0000536 ohms

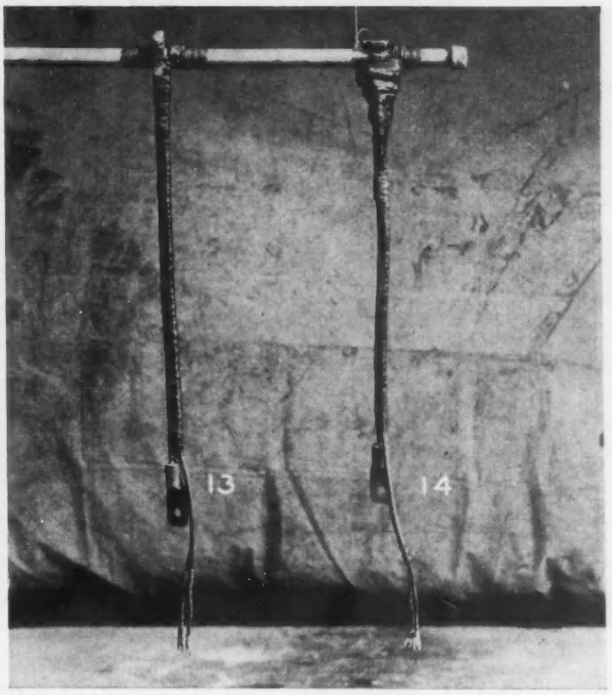

Fig. 6—Position 13—A-B-C clamp galvanized U-bolt bare (see detail C). Initial resistance, 0.0000047 ohms. Position 14—"E" clamp galvanized iron wire bare (See detail A). Initial resistance 0.0001286 ohms

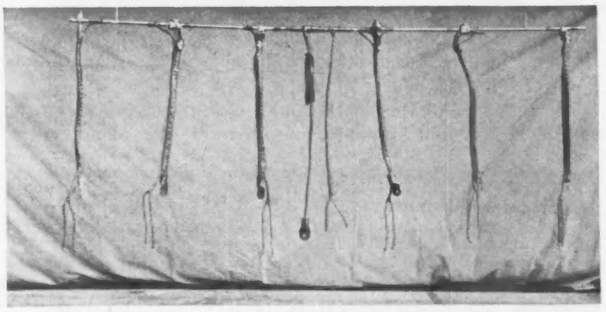

Fig. 7—Showing assemblage of six grounding clamps on a ⅝-in. by 8-ft. ground rod which was installed in the fortified soil. The descriptions of the several clamps, together with their initial resistances follow: Position 1 (left)—A-B-C standard ground clamp bare (see detail H). Initial resistance, 0.0000516 ohms. Position 2—"H" standard bare (see detail K). Initial resistance, 0.0000098 ohms. Position 3—A-B-C special bare (see detail J). Initial resistance, 0.0000163 ohms. Position 4—⅝-in A-B-C- standard ground rod clamp covered with pitch (130 deg. melting point). (See detail H.) Initial resistance, 0.0000407 ohms. Position 5—"H" standard bare (see detail K). Initial resistance, 0.0000133 ohms. Position 6—A-B-C- special bare (see detail J). Initial resistance, 0.0000188 ohms

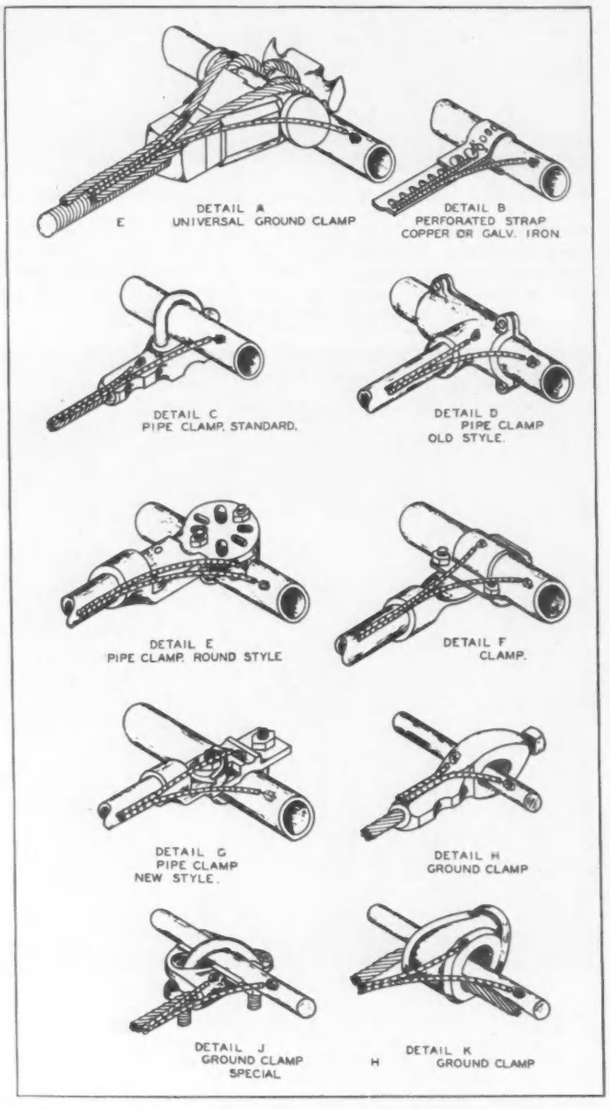

Fig. 8—Details of various styles of clamps

a new 1-in. galvanic pipe, such as is ordinarily used for water services. The same thing was done for the copper-plated driven ground rod. Two assemblages were prepared, one for soil exposure and one for atmospheric exposure. In order to accelerate the test somewhat, the soil was fortified by the addition of sodium chloride (common salt) to the amount of one pound of salt to one cubic foot of earth. Severe atmospheric exposure was found beneath the salt impregnated spray of a cooling tower.

It will be realized that an experimental investigation of corrosion must require considerable time. The life of a grounding clamp should extend over many years. Perhaps, with the accelerated corrosion to be secured under the severe conditions of atmospheric and soil exposure that are being provided, observations made over one year may begin to have some value.

At the conclusion of the test graphs will be made showing the change in the resistance of each clamp and a careful examination of rusting will be made. From these it is hoped that some definite conclusions may be drawn.

An exhibit of the assemblage and the various types of grounding clamps may prove of interest at this time.

Before the conclusions of our test, if this additional time is allowed us, an attempt will be made to make a supplementary report on (a) the seasonal variation of the resistance of driven rods, (b) soil treatment and its initial effectiveness, also its permanent effectiveness and (c) breaking and disconnecting possibilities.

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*High Resistance Areas**

THE performance of grounds under operating conditions, together with the various laws and regulations governing their installation, were covered quite completely by last year's subcommittee. Different types of ground connections and the resistance characteristics of each were discussed by this committee and the conclusions were drawn that every effort should be made to obtain ground connections to a water system where possible. This has been the conclusion of practically every investigation of this subject.

Water systems undoubtedly furnish the most satisfactory low-resistance grounding medium but, unfortunately, they are not available at all locations where grounds are required and thus artificial grounds, such as driven pipes or rods, are necessary. Reports of tests made upon ground pipes and rods indicate a wide variation of resistance values. In various types of soils and locations, also, a variation occurs beween seasons of the year.

In general the highest resistance values are encountered in soils composed mostly of rocks, gravel and sand, with practically no soil or loam. Such an area is found in and around Palm Springs in the Coachella Valley, Riverside County, California.

The following table gives the result of ground resistance measurements made in this area.

From the resistance values of the individual ground-rod installations it is quite evident that any expense incurred in placing ground rods in these areas is somewhat futile. It is hardly reasonable that a sufficient number of ground rods could be economically installed for practical resistance limits. In this installation of grounds care has been taken, in nearly every instance, to connect to some water system or other conducting medium to ground, in order that there should be no lesser resistance values or grounding surfaces with which to come in contact.

Such a solution of this problem appears adequate and while the resistance values in some instances are in excess

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* Prepared by E. Y. Porter, the Southern Sierras Power Co.

RESULTS OF GROUND RESISTANCE MEASUREMENTS ON PALM SPRINGS 4-KV. COMMON-NEUTRAL SYSTEM
MADE ON APRIL 29, 1930 and MAY 12, 13, and 14, 1930.

Pole No.	Test No.	Location	Resistance in Ohms Neutral Grid to Ground	Resistance in Ohms Individual Ground Con.	Type of Ground Connection
79065	1	Indian Ave., W/S., 100 ft. S/O Lemon St.	....	3.0	Waterpipe, 4-in.
79060	2	Indian Ave., W/S., 668 ft. N/O Lemon St.	....	0.5	Waterpipe, 4-in.
79057	3	Indian Ave., W/S., 151 ft. S/O North St.	....	9.0	Waterpipe, 4-in.
79054	4	Indian Ave., W/S., 374 ft. N/O North St.	....	6.4	Waterpipe, 4-in.
79050	5	Indian Ave., W/S., 1,053 ft. N/O North St.	0.6	0.6	Waterpipe, 4-in.
79045	6	Indian Ave., W/S., 760 ft. S/O Tachevah Dr.	2.5	2.5	Waterpipe, 4-in.
7?044*	7	Indian Ave., W/S., 791 ft. S/O Tachevah Dr.	1.7	1.7	Waterpipe, 4-in.
79040	8	Indian Ave., W/S., 168 ft. N/O Tachevah Dr.	0.7	0.7	Waterpipe, 4-in.
79037	9	Indian Ave., W/S., 899 ft. N/O Tachevah Dr.	3.7	3.55	Waterpipe, 4-in.
79034	10	Indian Ave., W/S., 1,619 ft. N/O Tachevah Dr.	....	5.0	Waterpipe, 4-in.
34049	11	Tachevah Dr., N/S., 348 ft. E/O Indian Ave.	....	1.0	Ser. side water meter with meter jumpered.
34304*	12	Tachevah Dr., N/S., 1,291 ft. E/O Indian Ave.	11.0	100.0	Two 8-ft. rods.
34313	13	Unnamed St., E/S., 522 ft. S/O Tachevah Dr.	12.5	12.0	Well casing.
34115	14	P. P., 185 ft. E/O Avenida De Los Palos Verde	1.5	1.5	U. G. ser. cond. and ¾-in. waterpipe.
34093	15	Hermosa Pl., S. S., 172 ft. W/O Main Ave.	125.0	130.0	Waterpipe, 4-in.
34097	16	Via Lola, N/S., 310 ft. W/O Camino Del Corto	80.0	80.0	U. G. ser. cond. and 2-in. waterpipe.
34189	17	P. P., 303 ft. S/O Via Lola W/O Orange Ave.	125.0	130.0	U. G. ser. cond. and ¾-in. waterpipe.
34005*	18	Camino Del Centro W/S., 595 ft. N/O Via Lola	90.0	90.0	Waterpipe, 2-in.
34405*	19	P. P., 500 ft. W/O Camino Del Centro	8.5	635.0	One 8-ft. driven rod.
34248	20	P. P., 328 ft. N/O Via Lola W/O Main Ave.	3.5	3.6	Waterpipe, 4-in.
34104	21	P. P., 514 ft. E/O Indian Ave., N/O Tamarisk Rd.	3.4	3.4	U. G. serv. cond. and ¾-in. waterpipe.
34349	22	Avenida De Los Palos Verde E/S., 103 ft. S/O Tamarisk Rd.	....	21.0	Waterpipe, 2-in.
34314	23	P. P., 80 ft. E/O Indian Ave., S/O Via Colusa	170.0	170.0	U. G. serv. cond. and ¾-in. waterpipe.
34359	24	P. P., 575 ft. E/O Indian Ave., S/O Via Colusa	140.0	140.0	Waterpipe, 2-in.
34363	25	P. P., 1,126 ft. E/O Indian Ave., S/O Via Colusa	150.0	150.0	U. G. serv. cond. and ¾-in. waterpipe.
34146	26	Lawn St., N/S., 290 ft. W/O Main Ave.	1.1	1.2	Waterpipe, 2-in.
34151	27	P. P., 1,350 ft. W/O Main Ave., N/O Spring St.	2.5	25.0	U. G. serv. cond. of considerable length.
34123	28	Palm Ave., E/S., 500 ft. N/O Lawn St.	2.9	3.2	Waterpipe, 2-in.
34127	29	Palm Ave., E/S., 757 ft. S/O North St.	10.0	10.5	Waterpipe, 2-in.
34053	30	North St., S/S., 129 ft. E/O Palm Ave.	7.8	8.3	Waterpipe, 2-in.
34012	31	P. P., 150 ft. N/O North St. opposite Palm Avenue	16.0	16.0	Waterpipe, 2-in.
34057*	32	North St., S/S., 375 ft. W/O Palm Ave.	1.7	....	None
34058	33	North St., S/S., 542 ft. W/O Palm Ave.	3.6	3.6	Waterpipe, 4-in.
34063	34	P. P., 158 ft. N/O Chino Dr., W/O North Orange	5.0	4.8	Serv. side of water meter with meter jumpered
34014	35	P. P., 540 ft. N/O Chino Dr., W/O North Orange	....	6.8	U. G. ser. cond. and ¾-in. waterpipe.
34072	36	P. P., W/O West Ave., opposite Merito Place	4.0	4.0	U. G. ser. cond. and ¾-in. water pipe.
34327*	37	Mountain View Place, S/S., 200 ft. W/O West Ave.	6.9	160.0	Two 8-ft. rods.
34330*	38	West Ave., W/S., 95 ft. S/O Hermosa Place	12.0	....	None.
34331	39	P. P., 200 ft. E/O West Ave., 95 ft. S/O Hermosa Pl.	1.8	1.0	Serv. side of water meter and meter jumpered
34082	40	Merito Pl., N/S., 275 ft. W/O Mission Rd.	3.4	3.4	Waterpipe, 2-in.
34087	41	P. P., 320 ft. S/O Hermosa Pl. and 275 ft. W/O Mission Rd.	4.7	4.5	U. G. serv. cond. and ¾-in. waterpipe.
34079	42	P. P., bet. Orange and Palm 252 ft. S/O Merito Pl.	2.5	2.2	Waterpipe, 4-in.
34295	43	P. P., bet. Orange and Prospect 252 ft. N/O Merito Pl.	6.5	6.5	Waterpipe, 4-in.
34335	44	P. P., bet. Orange and Prospect 200 ft. S/O Hermosa Pl.	12.0	10.0	Waterpipe, 4-in.
34320	45	P. P., bet. Main and Prospect 460 ft. N/O Chino Dr.	6.6	6.5	Serv. side of water meter and meter jumpered
35604	46	Indian Ave., W/S., 442 ft. S/O Lawn St.	0.55	0.75	Waterpipe, 4-in.
35599	47	Indian Ave., N. W. corner of Park St.	2.2	2.2	Waterpipe, 4-in.
35594	48	Indian Ave., West Side, 55 ft. S/O Lime St.	3.55	3.55	Waterpipe, 4-in.
35590	49	Indian Ave., West Side 650 ft. S/O Lime St.	2.55	2.50	Waterpipe, 4-in.

of those commonly required, since no other conducting earth medium is of a lesser resistance value, it seems entirely reasonable to assume that the most practical protective grounds have been secured and that electrical hazards due to failures are thus reduced to a minimum.

*Multiplicity of Ground Connections**

The subject of multiplicity of ground connections was so thoroughly covered by the subcommittee of last year that little was left to be accomplished this year except studies of particular phases. It is intended to avoid, as much as possible, any duplication of last year's work, which is too recent to be reviewed at this time. No definite conclusions, other than those made last year, can be arrived at from the observations made since that time.

THAT multiple grounding is to be preferred for greater protection to life and property and for the dissipation of a greater amount of energy is now an established fact.

Multiple grounding was covered by the Bureau of Standards Technologic Paper No. 108, reporting on its work of 1915 to 1917. Very little new, so far as theory and principles are concerned, has been brought out since that time. The theories are sound. The experiences of member companies may suggest practical conclusions which will depart slightly from the theoretical. More intensive studies have been given the subject during recent years because of the common neutral installations and the increase in the energy to be dissipated by grounding systems.

The object of this paper is to present the additional information obtained during the past year and certain observations made on grounding principles in the course of the work. Most of the information was obtained from one source only, that of a member company operating in the Sacramento Valley, and covers chiefly substation grounding. The work being carried on is of great interest to both the overhead systems committee and the electrical apparatus committee and can, therefore, be handled by either. The report is not complete and should be continued next year.

Advantage of Multiplicity Ground Connections

The Bureau of Standards paper referred to above states as follows:

> That part of the total resistance contributed by the soil is the most important in nearly all cases. When current flows away from the electrode, each element of current traverses a path of variable cross-section to its destination, which in practice is always another electrode at some distance away. The resistance offered by the soil, then, is the combined resistance of all the paths of the current elements in parallel, and since the resistivity of soil is high, this resistance will be high unless the electrode is very large and the comparative number of paths, therefore, very great.

From the tests shown in this report, it is desirable to ground electric circuits at more than one point, which is fast becoming the general practice. The following advantages of multiple ground connections can be given:

1. The protection against high voltage is not so likely to be destroyed by failure of one or more of the ground wires.
2. The greater the number of connections to earth, the less the possibility of a dangerous rise of potential between circuit and ground in the event of a failure of insulation or accidental contact between wires.
3. Multiple-ground connections will, when necessary, dissipate greater amounts of energy without material changes in their re-

* Report prepared by E. A. McGinty, Pacific Gas and Electric Company.

sistances. The conditions may be such that the current flow through the ground connection is not sufficient to operate the protective devices, and excess heating may occur before the fault is removed, unless the resistance is low. It appears from tests made by the Bureau of Standards that, " . . . . the relative capacity of ground connections to dissipate energy are not reliably indicated by their resistances, at least not for electrodes of the same size and shape." Multiple grounds are, therefore, more reliable.

4. The earth is not made of a homogeneous material and locations only a few feet apart often differ greatly in electrical conductivity. This can be seen by referring to Tables I or II. Multiple grounds will average up this condition.

5. The cost of certain types of multiple grounds, such as rods or pipe driven 8 ft. to 20 ft. in the earth, is much less than a well to a greater depth and, in most cases, provides lower resistance paths.

Distribution Circuit Grounding

The grounding of the neutral of star-connected primary distribution circuits has, until recent years, been done at the station only, by most companies. One of the earliest cases of multiple grounding of such systems to water pipes, was that in Sacramento described in last year's report. The neutrals of some systems in the vicinity of Sacramento, where water pipes were not available, were grounded by sinking 1-in. pipes to a depth of 30 ft. at various points along the circuits. Some of these grounds in a hardpan area tested from 2.5 ohms to 3.3 ohms in the dry season. It is interesting to note that one of the grounds referred to above tested 3.3 ohms, while a secondary neutral ground consisting of an 8-ft. rod on the opposite side of the pole tested 42.0 ohms.

Common Neutral

No information of value has been obtained this year on common neutral grounding. Multiple grounding is the only answer to this problem, and it resolves itself into the question of the best type to use under the existing conditions. Water pipe grounds are usually used when available for this purpose. The question of load densities of the areas under consideration and the maximum currents to be expected under fault conditions, govern, to a large extent, the number of grounds required.

The problem in thickly settled areas is greatly simplified by the National Board of Fire Underwriters' and the California Utilization Safety requirements that the neutral of all 110/220-volt services be grounded. Also the practice of member companies of grounding the secondary neutral at the pole, and in some cases, additional secondary grounds along the secondary system reduces the probability of harmful potentials from failure of transformers between primary and secondary and contact between high and low voltage wires, to a very low value.

The common neutral will probably not be carried to any great extent into sparsely settled areas, so that the grounding problem will not be serious. The loads are scattered and the number of grounds consequently fewer, increasing the probabilities of dangerous conditions arising, but, on the other hand, the currents to be carried are smaller under normal operating conditions and, as a consequence, the protective devices are set at lower tripping values. Many of the companies are installing more sensitive ground relays at the substations for better protection and more correct realay operation.

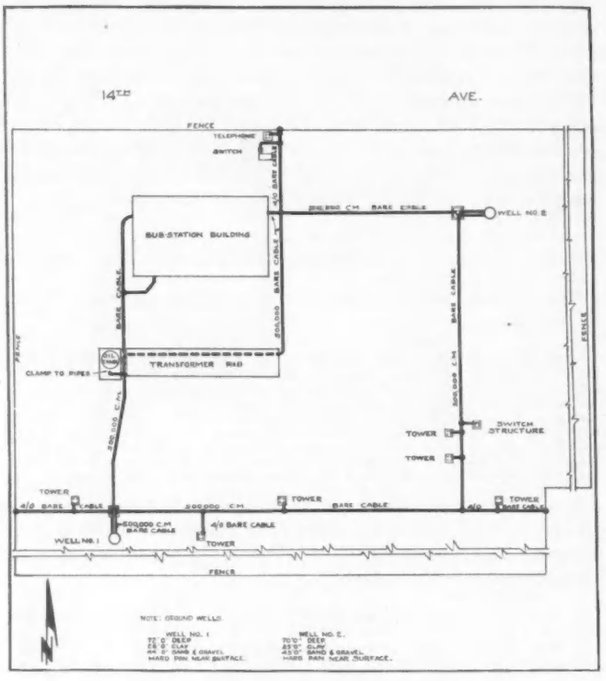

Fig. 1—Arrangement of ground cables and electrodes—station No. 1

Station Grounding

The problems met with in station grounding are similar to those of distribution lines. Grounding wells of more or less elaborate construction have been used to a large extent, but recent tests have proved beyond a doubt, in the particular localities tested, that the use of multiple-ground electrodes make for lower resistance grounds. It is important, as shown above, that the number of electrodes be sufficient to dissipate all the energy necessary under fault conditions without danger of burning off the ground wires or the electrode, or drying out the earth surrounding the electrode. While water-piping systems are of relatively low resistance, they probably should not be solely depended upon for power grounding at stations.

Where stations are so located that it is impossible to drive rods, such as rocky formation, fairly good results can be obtained by approximating a solid grid by means of cable laid in the earth. The resistance of such a ground grid will, no doubt, vary greatly with the seasons and the cost is relatively high. No recent tests are available on this type of ground, but it is the intention of one member company to install such a ground in the near future and tests will be available for next year. The ideal arrangement for grounding any station would be to install a solid plate of metal under the entire station and extending some distance beyond. There could be no serious results should the potential of the plate rise to a high value, say 2,000 volts above ground, so far as the station itself is concerned. This argument can be used in favor of protecting a man while operating gang-switches on steel framework by means of a metal grid under his feet, electrically connected to the tower. This would eliminate all insulating devices for the operation of the switch.

Some interesting tests were recently made on the grounding systems of new stations in the Sacramento Valley, showing the value of cable network. Two deep wells were installed at each of Stations No. 1 and No. 2 with the wells and all equipment to be grounded, tied together with 4/0 and 500,000 circ.mil copper cable buried 16 in. in the earth. See Figures 1 and 2 for arrangement of the grounds and Tables I and II for the results of tests. In the first case, (Fig. 1) the wells were 78 ft. deep through hard pan, and clay of 28 ft. into sand, gravel and water of 44 ft. The station capacity was 4,500 kva. and the voltage 60,000/4,000, star-star grounded neutral. The test was made Nov. 23,

TABLE I GROUND TESTS ON STATION NO. 1

EQUIPMENT UNDER TEST	READING TAKEN AT	RESIS. IN OHMS
SYSTEM	WELLS #1&2	0.03
WELL NO. 1	WELLS #1	4.50
WELL NO. 2	WELLS #2	4.50
FENCE	WELLS #2	0.04
SYSTEM WITH WELL NO. 1 DISC.	WELLS #1&2	0.03
SYSTEM WITH WELL NO. 2 DISC.	WELLS #1&2	0.03
SYSTEM WITH BOTH WELLS DISC.	WELLS #1&2	0.03

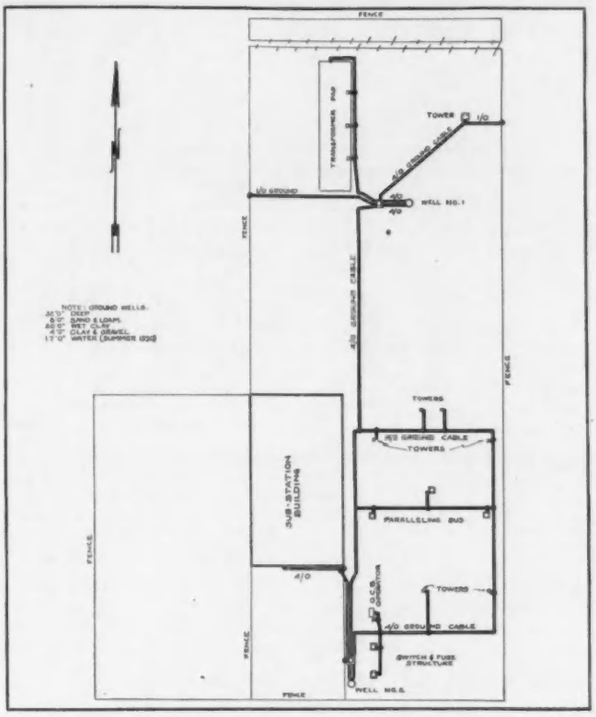

Fig. 2—Arrangement of ground cables and electrodes—station No. 2

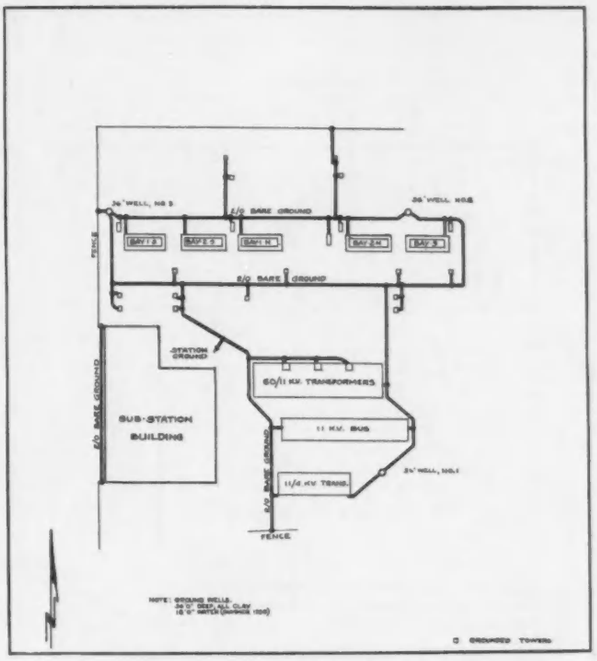

Fig. 3—Arrangement of ground cables and electrodes—station No. 3

1931 while the earth was slightly wet to a depth of from twelve to eighteen inches. As shown in Table I, each well disconnected tested 4.5 ohms, while the cables alone tested 0.03 ohms.

In the second case (Fig. 2.) the wells were 32 ft. deep through 20 ft. of clay, then 8 ft. of sandy loam, into 4 ft. of clay and gravel. At the time of installation, summer season, there was 17 ft. of water in the well. The station capacity was 6,000 kva. and the voltage 60,000-2,300/11,000. The test was made Nov. 27, 1931 while the earth was wet to a depth of twelve inches. As shown in Table II, the average resistance of the wells disconnected was 1.56 ohms, while that of the cables above was 0.04 ohms. Ground tests made on this station later in the wet season, after heavy rains showed very little change in the resistance. The electrodes in both of the above cases consisted of a grid of five pieces of 1¼-in. O.D. by 14-gage copper tubing 12 ft. long, connected together at top and bottom with ¼x3-in. copper bus bar in a 10-in. diameter circle. The electrodes were dropped to the bottom of the wells and connected to the cables above by two 500,000 circ.mil cables.

The third case (Table III and Fig. 3) is similar to the above with a 1,500-kva. station, 60,000-2,300/11,000 volts, with three 36-ft. wells and single 1¼-in.x12-ft. pipe electrodes. Tests were made on the same day as in Fig. 2, under the same conditions.

The grounding of substation fences seems to be a problem, the solution of which brings forth some argument by member companies. It seems to be the usual practice to tie the fence and station grounds together. The fences are usually constructed of metal with iron posts in the earth, or when wood posts are used, with the metal wire contacting the earth. It is in itself a multiple-ground connection and will have a definite resistance to earth which may, or may not, be comparable to the resistance of the substation ground which the fence incloses.

Table IV shows a comparison between power and fence

TABLE II GROUND TESTS ON STATION NO.2		
EQUIPMENT UNDER TEST	READING TAKEN AT	RESIS. IN OHMS
SYSTEM	WELL #1	0.05
SYSTEM	WELL #2	0.04
WELL #1	WELL #1	1.55
WELL #2	WELL #2	1.57
SYSTEM WITH WELL #1 DISC.	WELL #1	0.06
SYSTEM WITH WELL #1 DISC.	WELL #2	0.04
SYSTEM WITH WELL #2 DISC.	WELL #2	0.04
SYSTEM WITH BOTH WELLS DISC.	WELL #2	0.04

TABLE III GROUND TESTS ON STATION NO.3		
EQUIPMENT UNDER TEST	READING TAKEN AT	RESIS. IN OHMS
SYSTEM	WELL #1	0.10
WELL #1	WELL #1	1.67
SYSTEM WITH WELL #1 DISC.	WELL #1	0.10

NOTE: IT WAS IMPRACTICAL TO DISCONNECT WELLS NOS. 2 & 3 TO MAKE TESTS.

TABLE IV COMPARISON OF POWER AND FENCE GROUNDS IN STATION WHERE NOT CONNECTED		
STATION NO.	RESISTANCE IN OHMS	
	POWER GROUND	FENCE GROUND
1	0.03	0.04
5	2.8	14.5
6	36.0	300.+
7	8.2	12.5
8	6.5	300+
9	44.0	300+
10	4.8	16.3
11	0.05	1.5
12	6.0	58.0
13	13.2	31.0
14	15.6	270.0
15	2.8	300.+
16	17.0	160.0

NOTE: NONE OF THE FENCES WERE GROUNDED AT THE TIME OF TEST EXCEPT CONTACT OF THE WIRE FENCING WITH THE EARTH

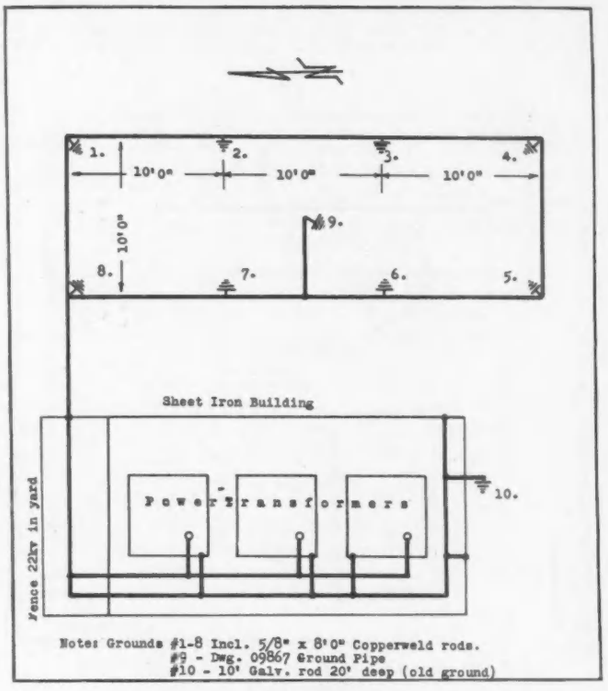

Fig. 4—Arrangement of ground cables and electrodes—station No. 4

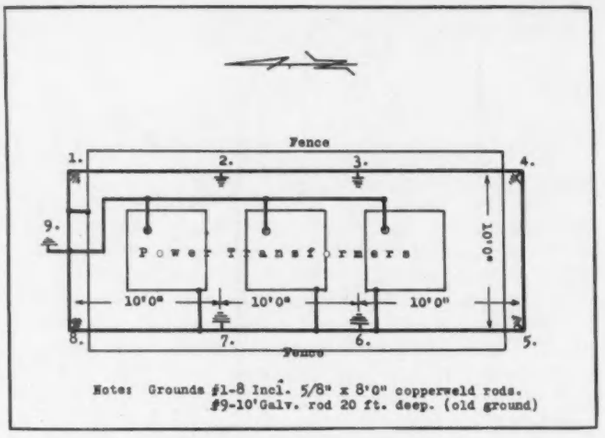

Fig. 5—Arrangement of ground cables and electrodes—station No. 5

grounds in stations where separate grounds are used and was prepared from actual tests made in the Sacramento Valley.

Ground Tests and Inspections

It is desirable to know as much as practicable of the electrical characteristics, especially the resistance, of a ground connection before it is put in service. It can be assumed that the capacity to dissipate energy is there, if the ground meets the requirements as to resistance and permanence. Therefore, the important test is that for resistance and some surprising results have been obtained by member companies when new grounds were tested. Installation tests alone are not sufficient for all time. Adequate and reliable protection can be afforded only by good mechanical construction supplemented by frequent inspections and occasional tests. From the meager information available from member companies it appears that few, if any, make regular and systematic inspections of ground connections. Multiple-ground connections will require less inspection than a single connection, as less dependence is placed on each element.

A recent resistance test of the ground connection on a small station near Sacramento, brought out the fact that the ground wire was open at the electrode, a single-electrode job, which probably prevented a serious accident. In another case, the single-electrode open connection was dis-

TABLE V GROUND TESTS ON STATION NO.4

		ELECTRODES IN PARALLEL		AVERAGE RESISTANCES	
ELECTRODE NO.	RESISTANCE OHMS	ELECTRODE NOS.	RESISTANCE OHMS	NO. OF ELECTRODES IN PARALLEL	RESISTANCE OHMS
1	13.2	1-8	9.6	1	13.75
2	10.7	2-7	5.8	2	7.35
3	14.0	3-6	6.3	4	3.90
4	20.2	4-5	7.3	6	2.90
5	11.0	1-2-7-8	4.0	8	2.35
6	10.4	3-4-5-6	3.8	9	2.15
7	10.5	1-2-3-6-7-8	2.9	10	2.00
8	28.4	1 to 8 Incl.	2.35		
9	8.5	1 to 9 Incl.	2.15		
10	10.6	1 to 10 Incl.	2.0		
AVERAGE	13.75				

TABLE VI GROUND TESTS ON STATION NO.5

		ELECTRODES IN PARALLEL	
ELECTRODE NO.	RESISTANCE OHMS	ELECTRODE NO.	RESISTANCE OHMS
1	3.3	1-8	2.0
2	5.3	1-2-7-8	1.3
3	6.0	1-2-3-6-7-8	1.0
4	6.8	1 to 8 Incl.	0.8
5	3.8	1 to 9 Incl.	0.7
6	4.3		
7	4.5		
8	3.1		
9	2.8		
AVERAGE	4.4		

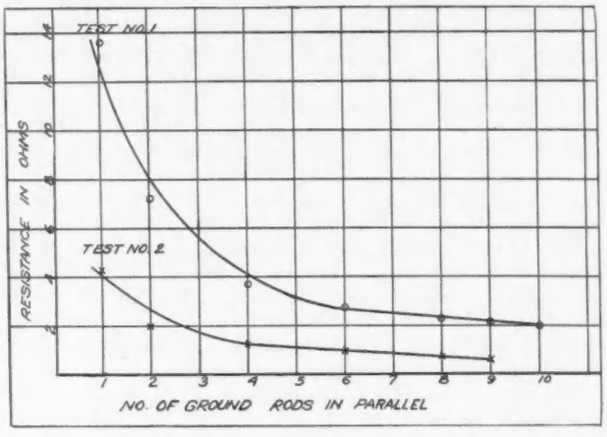

Fig. 6—Curves showing the effect on resistance of increasing the number of ground rods in parallel

covered by laying a piece of pipe across the primary neutral wire where it entered the earth, at a point between the open connection and the transformer. The arc thus produced warned of the danger. A serious accident might have occurred. Frequent tests and inspections will in many cases locate these troubles.

Some Routine Ground Tests

In addition to the tests previously mentioned in this paper, a number were made in the regular course of work on one company's system near Sacramento. Most of the ground tests were on small capacity, 150-kva. to 1,500-kva. stations,

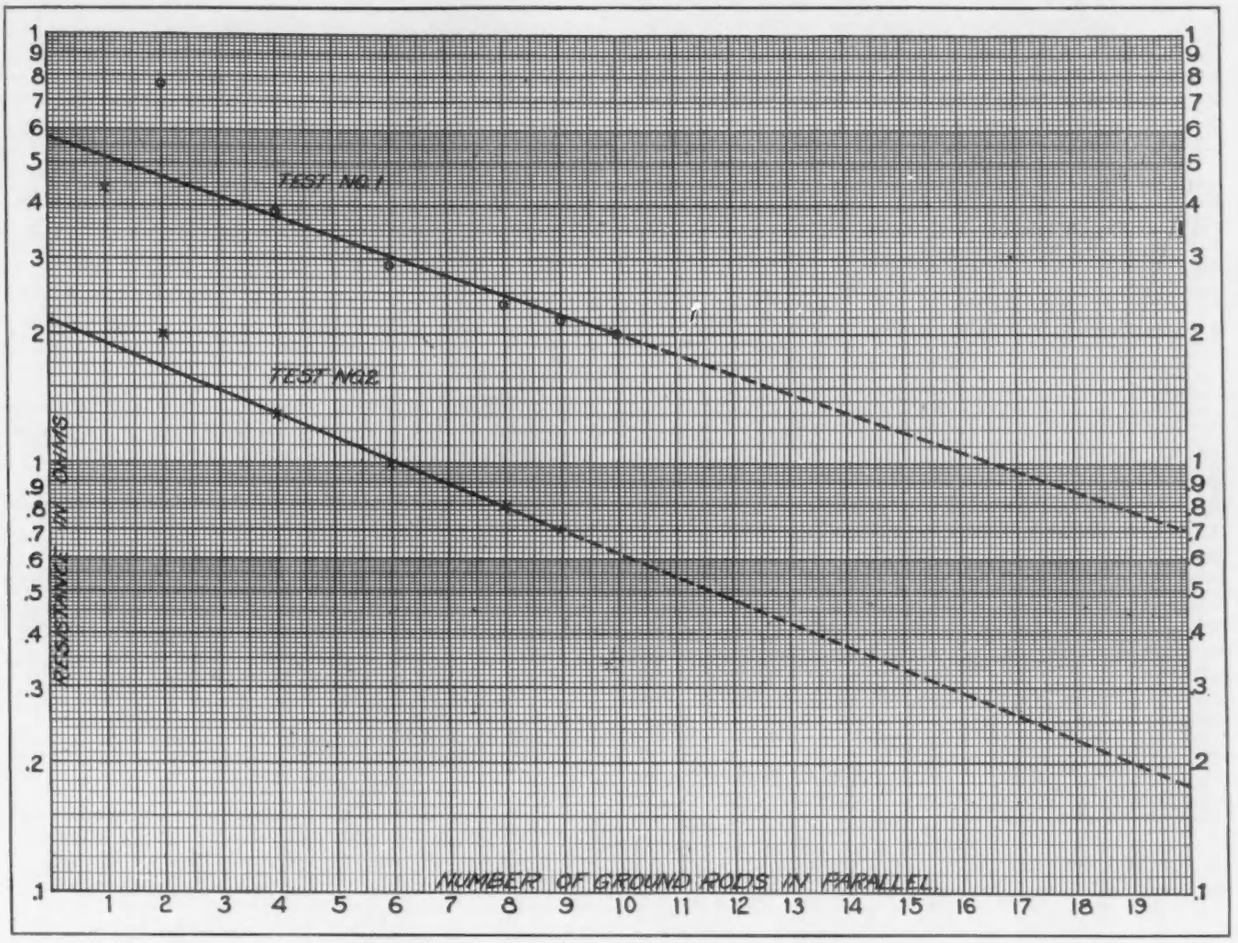

Fig. 7—Logarithmic curves showing the percentage effect on resistance of increasing the numbr of ground rods in parallel

some with single and some with multiple-electrode grounds. All single electrodes consisted of a 1-in.x10-ft. pipe installed to a depth of 20 feet and most of the multiple-ground electrodes consisted of ⅝-in.x8-ft. rods. All tests were made with a Biddle megger ground tester.

The grounding system was revamped in a small 22-kv./4-kv. station in an attempt to improve the ground resistance. Fig. 4 shows the arrangement of electrodes and Table V and Fig. 6 show the results of the test. The original ground, (No. 10) consisted of a 1-in. by 10-ft. galvanized iron pipe set 20 ft. deep. Eight ⅝-in. by 8-ft. ground rods (Nos. 1 to 8 inclusive) and one 1¼-in. by 12-ft. copper ground pipe (No. 9) were installed, as shown. Driving the rods was impossible due to the hard pan and very dry condition of the earth. The rods were installed by drilling holes with an auger to a depth of 15 ft., except No. 1 rod, which was set 22 ft. deep. This method of installation, due to the necessity of back-filling, gives a higher contact resistance than driving at the time of installation. A test made one week after installation in this case showed an improvement in resistance from 2.0 to 1.46 ohms. The rods and pipes were tied together with 3/0 bare copper cable after certain of the tests were made.

Another station grounding system was revamped, as shown in Fig. 5. The results of the tests are shown in Table VI and Fig. 5. In this case ⅝-in. by 8-ft. ground rods (Nos. 1 to 8 inclusive) were driven with heads to the earth's surface. The original ground (No. 9) consisted of a 1-in. by 10-ft. galvanized pipe, 20 ft. deep. All ground electrodes were tied together with 3/0 bare copper cable.

The curves of Fig. 6 show the effect on resistance of increasing the numbers of ground rods in parallel at the two stations mentioned above. The same curves are plotted on logarithmic paper in Fig. 7 to show the percentage change in resistance as ground rods are added in parallel. While the percentage drop continues the same, as electrodes are added there is a point reached where economy and effectiveness are balanced.

The following is an interesting case of revamping the grounding system of a small 22-kv./4-kv. substation. The original ground consisted of a 1-in. by 10-ft. pipe, 20 ft. deep, which tested 14.5 ohms in December, 1930. Later it was found necessary to replace the bank of transformers, at which time the ground was replaced by a 1¼-in. by 12-ft. copper ground pipe, 20 ft. deep. The power and all equipment ground-wire were tied together. The test showed a reduction to 8.2 ohms. In an attempt still further to reduce the resistance, six ⅝-in. by 8-ft. ground rods were installed 10 ft. apart. Holes, 8-in. in diameter, were drilled to a depth of 6 ft. and the rods driven from there. All rods were tied together with 3/0 bare copper cable and tested 1.62 ohms. This ground grid was then tied to the copper pipe, reducing the resistance to 1.48 ohms. The soil was a dry sandy loam.

Tests were also made on several station grounds in the vicinity of Sacramento, with results as shown in Table VII.

Conclusions

The following conclusions were reached by last year's committee:

There is no doubt as to the value and the necessity of adequate grounds. It is likewise obvious that the condition of maximum

TABLE VII MISCELLANEOUS GROUND TESTS	DRY SEASON		WET SEASON	
	SINGLE ELECTRODES	MULT. ELECTRODES	SINGLE ELECTRODES	MULT. ELECTRODES
TOTAL NUMBER OF GROUNDS TESTED	42	3	11	6
NUMBER OF GROUNDS BELOW 1 Ohm.	3		2	3
NUMBER OF GROUNDS BETWEEN 1 & 5 Ohms.	10	3	7	3
NUMBER OF GROUNDS BETWEEN 5 & 10 Ohms.	5			
NUMBER OF GROUNDS BETWEEN 10 & 25 Ohms.	10		1	
NUMBER OF GROUNDS BETWEEN 25 & 100 Ohms.	11		1	
NUMBER OF GROUNDS OVER 100 Ohms.	3			
MINIMUM RESIS. OF ALL GROUNDS TESTED	0.12	1.46	0.12	0.34
MAXIMUM RESIS. OF ALL GROUNDS TESTED	175.00	2.80	28.90	2.90
AVERAGE RESIS. OF ALL GROUNDS TESTED	27.70	1.91	4.95	1.24
NUMBER OF GROUNDS TESTING BELOW 25 Ohms.	28.0	3.	10.	6.
PER CENT OF GROUNDS TESTING BELOW 25 Ohms.	66.7	100.	91.	100.
NUMBER OF GROUNDS TESTING BELOW 5 Ohms.	14	3	7.	6.
PER CENT OF GROUNDS TESTING BELOW 5 Ohms.	33	100	64.	100.

safety is obtained when we have a multiplicity of grounds connected to the same copper grounding grid of suitable conductivity. . . . In general it may be assumed that the effective, combined resistance of parallel grounds is approximately inversely proportional to the number; the resultant division of current imposes less severe demands on the individual electrode. This is particularly true in network systems, and the laws of probability will have a direct bearing in setting up values of resistance in all areas of this type.

These conclusions cannot be changed or added to after another year of study on multiplicity of ground connections; they can only be emphasized. While actual tests do not show that combined resistance of parallel grounds is exactly inversely proportioned to the number, they show that the law is followed as closely as possible with a non-homogeneous earth to contend with. Tests have shown that for economy and effectiveness in multiple-ground electrodes, six or eight elements are sufficient.

Further study should be given this subject next year, especially regarding ground grids under stations and under switch-operating handles on steel structures; methods for areas where sufficiently low resistance cannot be obtained by the usual methods; whether or not fence grounds of stations should be tied to the station grounding system, and the maximum allowable resistance of a multiple ground system.

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*Types of Ground Electrodes**

A discussion of the most desirable ground electrode, taking into consideration practicability and expense involved as well as effectiveness.

ANY discussion of distribution grounding brings us to the question of the type of ground electrodes most desirable. It is generally agreed that the water system is the most effective ground, but it is not always possible or practicable to obtain it and it may be quite expensive. However, in a densely populated territory, it is quite important to secure the lowest ground resistance possible, which means that the local water system must be utilized as a ground. It is unnecessary at this time to consider details of the method of connecting the ground wire to the water pipe, as these details have been treated in a previous report on distribution grounding. It is sufficient to state that the connection must be rugged, must not endanger the water system, should have as low a resistance as practicable and that the cost should be kept within reasonable bounds.

In localities where the population density is not great or where no extensive water system is available, it is necessary to provide other means of obtaining an electrical ground. This brings us to the consideration of buried metal plates or strips, ground cones or driven pipes. For distribution work it is hardly practicable to go to the expense of digging a hole or trench to utilize metal plate or strip, even though certain tests have shown that the lowest resistance can be obtained with the least amount of metal when a long narrow metal strip is used as the electrode. For general distribution work this reduces the question to a discussion of the method of utilizing driven pipes. As reported in the Bureau of Standards Technological Paper No. 108, which has been used as a reference text on the subject of grounds for a number of years, the three methods of reducing the ground resistance of driven grounds are by:

1. Increasing the length of the pipe or rod.
2. Connecting the pipes or rods in multiple.
3. Treating the soil with common salt, calcium chloride, copper sulphate or some other inexpensive material of a like nature to reduce the original resistance value and to maintain the low value of resistance.

The effectiveness of each of the three methods of reducing the ground resistance is well illustrated in the paper referred to and need not be further considered in this report.

From the 1931 report on the same subject, submitted to the Pacific Coast Electrical Assn., the following facts were established:

1. Copper, bare iron, galvanized iron and other metals indicate practically identical contact resistance with the soil.
2. Very little change in resistance is obtained by using larger diameter rods and pipes. The soil surrounding the rod, rather than the diameter of the rod, determines the resistance.
3. Peneration into the permanent moisture level of the soil should be the aim in selecting the length of the driven electrode.
4. Additional reduction in resistance may be obtained by the use of two or more rods in parallel, with adequate separations between them.
5. Conductivity of the soil surrounding the rod may be increased by soil treatment, thereby reducing the resistance and the effectiveness of the electrical ground.

In 1929 Mr. Rovere and Mr. Agnew of the Western Union Telegraph Co. published an article on the subject of grounds which ties in quite definitely with this phase of the subject. Extracts from this article are presented, as follows:

The presence or absence of rust, zinc or other metal coatings or salts on the surface of metal electrodes imbedded in the earth does not seem to affect the contact resistance. Of course, paint and other insulating substances, such as oil and grease, will, while they last, increase contact resistance.

It may be of interest to know approximately the resistance of a made ground in various types of soils. The experience of the telegraph company, which in general agrees with that reported by others for similar conditions, and which is based upon the use of a driven pipe from 6 ft. to 10 ft. long, indicates that such an electrode driven in salt marsh will probably show a resistance of between 5 and 15 ohms. An electrode of the same size in black loamy soil would average a resistance of from 10 to 25 ohms, while if it were in clay, the resistance might be from 20 to 50 ohms. In gravelly loam, the resistance of such an electrode would range from 150 to 500 ohms, while in shale loam, the maximum might run up to 1,000 ohms. In sandy soils, such as those found in parts of Long Island and other seashore regions, it is seldom practicable to obtain a resistance of less than 500 ohms per electrode, and the resistance frequently is over 1,000 ohms. The range and the variations may appear wide, but they are no more so than the difference in soil and soil conditions.

The use of plates for grounding electrical systems is decreasing, due in most cases to the fact that the same results can be obtained more economically with driven pipes or rods.

As a large part of the total resistance of a ground is in the soil contained within a 1-ft. radius of the electrode, it is evident that much may be gained by dissolving in the soil some substance which is highly conducting in its water solution. Salt is the material most often used for this purpose, but calcium chloride and copper sulphate are also comparatively cheap and under certain conditions may be preferable to salt.

It has been our experience that good results can be obtained in the salting of ground by using from 60 to 75 lb. of coarse salt, applying it in a basin from 1 ft. to 2 ft. in radius and 1 ft. deep, dug around a driven ground. After the salt has been dumped in this basin, plenty of water is poured over the salt and the earth is then replaced above it.

It is our opinion that in general salting or similar artificial treatment of driven grounds to reduce the resistance is less desirable than the provision of multiple grounds. We base this opinion upon the greater stability of the resistance of multiple grounds and the difficulty of insuring the periodical replacement of these salts. In many cases it does not seem as though there should be much difference in labor cost between the driving of one additional ground as against the salting of the original ground.

Sufficient experience has been gained with the utilization of the water system on 4-kv. distribution systems to determine that the resistance of the neutral when connected to the water system is sufficiently low for all purposes. From numerous tests made, it is apparent that this applies in the

* Report prepared by E. R. Stauffacher, Southern California Edison Company Ltd.

case of separate high-voltage and low-voltage neutrals, as well as with the common neutral system. In rural distribution territories, however, where the distribution voltage is nominally 11 kv. or 16 kv. and where ground rods are used almost exclusively for obtaining a neutral or lightning arrester ground, the information is not so complete. Accordingly, during the past year, a number of tests were made at the end of the summer season and before the rainy season developed, to determine what the resistance of ground rods actually is. The development of portable self-contained ground-measuring devices now makes it possible to determine the resistance of a distribution ground rod in the field with considerably less effort and expense than was the case when it was necessary to provide an electrical connection for testing. The following tabulated tests on driven grounds were made in southern California between September and November, 1931, and covered all classes of soil ordinarily encountered:

TESTS ON DRIVEN GROUNDS
Sept., 1931, to Nov., 1931

Location Number	Type of Ground	Measured Resistance Value of Ground, Ohms
1	One 1-in. galv. iron pipe, 8 ft. long	90.0
2	One 1-in. galv. iron pipe, 8 ft. long	30.0
3	One 1-in. galv. iron pipe, 8 ft. long	5.0
4	One 1-in. galv. iron pipe, 8 ft. long	2.0
5	One 1-in. galv. iron pipe, 8 ft. long	300.0
6	One 1-in. galv. iron pipe, 8 ft. long	40.0
7	One 1-in. galv. iron pipe, 8 ft. long	9.5
8	Two ⅝-in. C. W. rods, 8 ft. long	135.0
9	Two ⅝-in. C. W. rods, 8 ft. long	175.0
10	One 1-in. galv. iron pipe, 8 ft. long	5.0
11	One 1-in. galv. iron pipe, 8 ft. long	285.0
12	One 1-in. galv. iron pipe, 8 ft. long	5.0
13	Two ⅝-in. C. W. rods, 8 ft. long	245.0
14	One 1-in. galv. iron pipe, 8 ft. long	300.0
15	One 1-in. galv. iron pipe, 8 ft. long	39.0
16	One ⅝-in. guy wire tied to anchor rod	300.0
17	One 1-in. galv. iron pipe, 8 ft. long	126.0
18	One 1-in. galv. iron pipe, 8 ft. long	1.5
19	One 1-in. galv. iron pipe, 8 ft. long	125.0
20	One 1-in. galv. iron pipe, 8 ft. long	140.0
21	One 1-in. galv. iron pipe, 8 ft. long	150.0
23	One 1-in. galv. iron pipe, 8 ft. long	130.0
24	Two ⅝-in. C. W. rods, 8 ft. long	170.0
26	One 1-in. galv. iron pipe, 8 ft. long	53.0
27	Two ⅝-in. C. W. rods, 8 ft. long	60.0
28	Two ⅝-in. C. W. rods, 8 ft. long	1.5
29	One 1-in. galv. iron pipe, 8 ft. long	105.0
30	One 1-in. galv. iron pipe, 8 ft. long	18.0
31	One 1-in. galv. iron pipe, 8 ft. long	75.0
32	One 1-in. galv. iron pipe, 8 ft. long	21.5
33	One 1-in. galv. iron pipe, 8 ft. long	4.4
34	One 1-in. galv. iron pipe, 8 ft. long	16.0
35	One 1-in. galv. iron pipe, 8 ft. long	14.5
36	One 1-in. galv. iron pipe, 8 ft. long	14.0
37	One 1-in. galv. iron pipe, 8 ft. long	0.7

SUMMARY OF ABOVE TABLE

Resistance Limits Ohms	Number of Grounds	Percentage
0- 10	9	25.7
10- 25	5	14.3
25- 50	3	8.6
50-100	4	11.4
100-200	9	25.7
200-300	5	14.3
Total	35	100

Types of soil of ground-rod locations in observed order of the resistance of ground rods:
1—Clay and adobe (lowest resistance)
2—Loam
3—Sandy loam
4—Wet sand and gravel
5—Dry sand, gravel and boulders (highest resistance)

From the above tabulation, it is apparent that there is no consistency in the resistance value from the standpoint of using 1-in. galvanized iron pipe or ⅝-in. copperweld rods as the grounding device. The difference in resistance values encountered can be attributed entirely to the class of soil and to the moisture present in the soil at the time of the test. This would indicate that it is necessary to use either more ground rods in parallel or to treat the soil artificially, if the desirable low-resistance grounds are to be obtained in all types of soil. Some companies have avoided the use of salt or copper sulphate because of the difficulty of transporting this material on the same trucks where the miscellaneous tools and equipment are transported. However, there is little doubt that if good electrical grounds having a low resistance are to be obtained, there are many localities where artificial treatment must be used. This means that salt to the extent of 50 to 100 lb. per rod must be used rather than 5 to 10 lb., which has been the practice with some of the companies in the past. Under certain conditions, the use of a buried copper cable extending a few hundred feet on each side of the transformer pole will form a satisfactory ground where it would be practically impossible to obtain such a ground by the use of driven pipe alone. This applies to rocky and sandy soils having very little moisture content and where the use of salt would not be permissible.

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*Solderless Wire Connectors**

This report is a study of solderless connectors used for making electrical and mechanical connections on taps and wires where the joint is not subject to tensile stresses other than its own weight.

Solderless Connectors

THE use of line connectors, a mechanical device for clamping two or more electrical conductors together, has greatly increased as a substitute for the conventional twisted wire tap or splice.

Soldered Splices

On secondary circuits of 5,000 volts and under, the twisted wire taps and splices have been soldered. On higher voltage circuits they are usually left unsoldered.

Solder is necessary to secure a tight joint of high conductivity. Unless solder is used, the conductors may become oxidized and sometimes become very loose. Soldering requires the application of heat which may anneal the copper and which reduces its tensile strength. A torch and associate equipment, such as a gas tank, fluxes, etc., are necessary. Soldering upon a pole is always cumbersome and requires considerable time.

Twisting and connecting large conductors is also a slow and laborious task. Removal of a soldered tap is very slow and sometimes injurious to the main line conductor. Usually it is cut off and the twisted wire of the tap left in place.

Purpose of a Connector

The purpose of a connector is to produce a connection between wires carrying electricity, equal to or better than the universal twisted wire tap at a smaller cost.

Requirements of Solderless Connector

The purpose noted above requires that a solderless connector must have the following characteristics:

1. Mechanical strength.
2. Non-corrosive.
3. Good conductivity.
4. Remain tight regardless of vibration.
5. Must not cause radio interference.
6. Adaptable or easy to install and remove.
7. Adaptable to live lines.

Material

To produce a strong non-corrosive connector with high conductivity, brass, bronze, hard copper and an alloy of silicon, manganese and bronze, has been used in its manufacture.

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* Report prepared by J. R. Jensen for the subcommittee on line conductors, overhead systems committee, Engineering Section. F. E. Dellinger, chairman. R. G. Boyles, J. E. Crilly, Walter Hayes, C. E. Heath, J. R. Jensen, C. T. Mess, J. B. Moorhead, R. W. Muller, A. C. Putman, R. M. Spencer, C. C. Wilson, H. H. Shields.

Brass is the most commonly used, as it has fair conductivity, has high resistance to corrosion, is quite strong, and is low in cost.

An interesting report on "Copper and Copper Alloys" was read before the overhead systems committee at Baltimore, Jan. 23, 1930, by W. H. Bassett of the American Brass Co.

Following are a few interesting statements which will be of value in choosing connectors for line work:

a. Yellow brass has 60 to 70 per cent copper, and 40 to 30 per cent zinc. It has a high resistance to corrosion and less than 25 per cent conductivity. On account of internal stresses, due to cold working, it is liable under outside atmospheric exposure to intercrystalline fracture, commonly known as "season cracking."

b. Red brass has 80 per cent copper, 20 per zinc, high corrosive resistance, 25 per cent conductivity, and is not subject to season cracking under ordinary atmospheric exposure.

c. An alloy of silicon-manganese bronze, consisting of 96 per cent copper, 3 per cent silicon, and 1 per cent manganese. It has very high strength and high corrosive resistance, but has only 6 per cent conductivity. In this report it will be referred to as "silicon alloy."

d. Bronze or tin alloys consisting of 98.8 to 99.5 per cent copper and 1.2 to 0.5 per cent tin have high tensile strength and high corrosive resistance, but the conductivity is reduced to values varying from 35 to 65 per cent and they become "hot-short" when overheated—that is, the alloy in a measure decomposes when brought to annealing temperatures.

e. Copper (hard) has less tensile strength and corrosive resistance than copper alloys, but it has a conductivity of 96.16 per cent or over.

Types of Connectors

There are on the market a large variety of connectors made of different kinds of metals and alloys. The types can be divided into the following classifications:

1. U-bolt-type, patterned after the U bolt.
2. Vise-type, patterned after the bench vise.
3. Clamp-type, patterned after the standard 2- or 3-bolt clamps used for guying.
4. Wedge-type, patterned after the common wedge.

It is noted that the idea back of each principle is to obtain a compressive stress of high intensity between the conductors

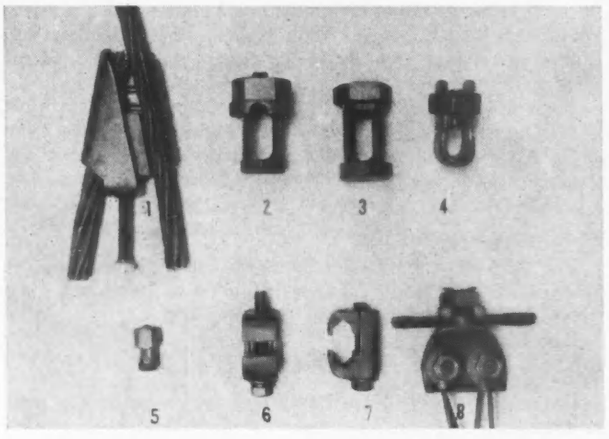

Fig. 1—Types of connectors: (1)wedge-type, hard copper (2) U-bolt type, brass and bronze (3) U-bolt type, brass and bronze (4) U-bolt type, hard copper (5) U-bolt type, brass and bronze (6)Vise-type with lock washer, silicon alloy (7) Vise-type without lock washer, silicon alloy (8) multiple-service connector, forged copper

or contacting units in order to reduce the contact resistance to a minimum.

Questionnaire and Test

In order to find out the characteristics of the various types of connectors on the market, a questionnaire was sent to six electric utility companies in California. One large company made a thorough test on several of the above types, from which valuable information was obtained. Each type was tested, the information obtained on the requirements of a connector being as follows:

1. Mechanical Strength

Tensile tests were made on joints made up with connectors. Tests were also made to determine the amount of tightening the connectors would stand without distortion or failure.

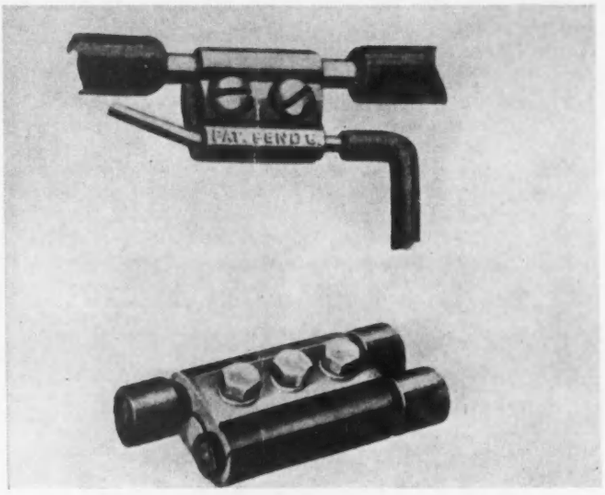

Fig. 2—Clamp-type, brass and copper

The tensile holding strength of all the connectors was found very low compared to that of the wire itself. The holding power is largely dependent on the metal from which the connector is made. The order is (best first) brass, silicon alloy, bronze and copper. An exception was the copper wedge-type connector, which tested very effectively, particularly on large stranded conductors.

In tightening the various types of connectors until they distorted or failed, it was noted that the U-type made of brass and bronze was strongest. Those made of copper distorted under the ordinary stress of making up a connection.

A small wrench should be used on the wedge-type and vise-type, as the wedge and the larger number of threads on the bolts, compound the forces in such a way that less pressure is necessary on the bolt.

No time-tests were made to determine if the jaws of the vise and wedge types will part and cause a loose connection over a period of time.

Threads did not shear, except in a few cases when extreme force was applied.

2. Corrosion

All connectors used and tested, included in this report, are made of non-corrosive materials. Reports from the field do not indicate any corrosion or indications of "season cracking."

3. Conductivity

Conductivity tests were made by connecting connectors of a size in series on wire or cable, passing current through the loop and measuring the temperature rise in each connector and wire itself after one hour.

The test was made first by putting the connectors on uncleaned wire. The test was then repeated with the connectors applied on the wire after it had been cleaned with emery cloth. Then, without loosening the connectors, the connections were attached to a vibration machine. They were subject to a 1/16-in. amplitude for a period of 125 hr.,

after which they were again subjected to a conductivity test.

Conductivity test, on a multiple-service connector, together with several conductors in a U-bolt, wedge, and vise, connector, was made.

Conductivity of joints made with connections on corroded wire was very poor, the temperature being many times that of the conductor itself in some cases.

On corroded wire the wedge-type connector showed the best conductivity. This was probably due to contact surfaces of the wedge being knurled and in tightening tending to scrape the surface of the wire clean.

The connectors all have better conductivity on clean wire than the wire itself.

The conductivity of connectors depends largely on the metal from which it is made, the order being copper, bronze, silicon alloy, and brass.

However, the connectors showing the best conductivity were:

1. Vise type.
2. Wedge type.
3. Bronze U-bolt type.

It is interesting to note the high conductivity of the wedge-type, despite the fact that the current must pass through it, insead of directly from conductor to conductor as with other types.

The multiservice connector has better conductivity than the U-bolt, wedge and vise types.

4. Vibration

Vibration tests made were made as described under "conductivity." The connectors were also subjected to a vibration test at a frequency of 20 cycles per second. The wire (No.6) to which they were attached was under normal stringing tension, and a weight equal to 5 ft. of bare wire (No. 6) was hung on the tap wire.

Vibration does not tend to loosen any of these connectors, but does tend to increase the conductivity of the connections.

Vise-type connectors, with lock washers, have no advantages over those without the washers. Special provisions for locking the nut were found unnecessary.

5. Radio Interference

No laboratory tests were made on radio interference. Reports from the field indicate only a case or two of radio interference due to a loose connector. No radio interference should be noticed as long as the connector remains tight. Results from the vibration would indicate very little trouble from this source.

6. Adaptability

Generally, for ordinary connections on low-voltage or dead circuits, all of the connectors are easily and quickly applied.

The U-bolt type requires that it be taken apart and placed over the two or more conductors to be connected. The nut assembly is placed over this and the wires are thus clamped together. Uniform compressive stresses are produced on all sides of the joint, insuring good contact and mechanical strength. The wires are in direct contact with each other under a high concentrated pressure, which should produce high conductivity.

The necessity for assembling the two parts over a loose connection upon a pole may be rather cumbersome, particularly when rubber gloves or live-line tools are used. The bevel on one of the U-bolt-type connectors makes it very much easier to assemble.

The vise type is a single unit and easier to place over the wires than the U-bolt type, particularly on live-line work.

The wires are placed in direct contact with each other, which gives the joint high conductivity. Due to the open side of this type of connector, there may be a possibility, where several conductors are placed in one connector or extra flexible stranded conductors are used, for the strands to squeeze out, thus reducing the pressure on the joint, thereby increasing its resistance. The strain on the connector is entirely on one side, thus causing a lever action which in time may cause the vise to spread.

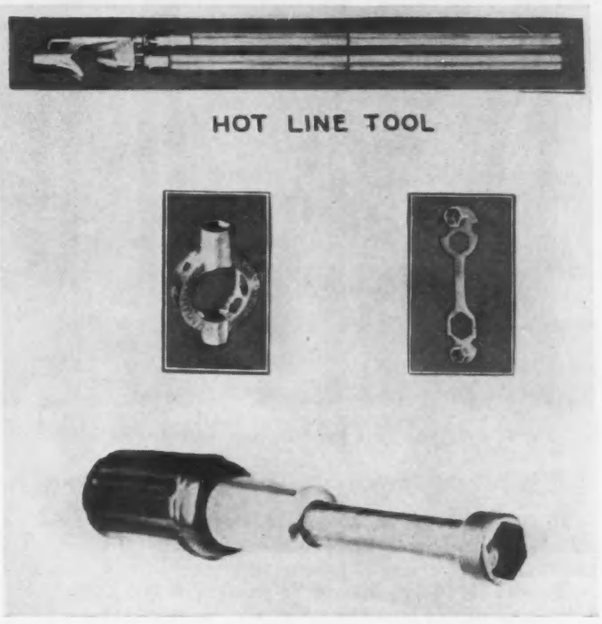

Fig. 3—Various types of patent tools for installing solderless connectors

Wedge-type connectors are not quite as easy to install. The wires are not brought in direct contact with each other; hence there are two contacts in series. However, the wedge and large contacting surfaces make a good low-resistance joint. Due to the one side being open, it is subject to a heavy strain, which may in time cause the wedge to become loose. It is not suitable for more than two conductors.

Clamp-type connectors have been used to a considerable extent on small conductors. They appear to be easily installed, although the screws are quite small for the type of work that linemen are accustomed to do. The two conductors are kept entirely separated, which makes this type adaptable for the connection of unlike conductors, such as copper to iron. This is often done in telephone circuits.

The multiple-service connector is very easy to install. It has the advantage that until all the taps for which it has been designed have been used, additional taps may be made without disturbing the original connections.

7. Application to Energized Lines

Reports from the six California electric utility companies indicate that the U-bolt type of connector is most widely installed on 4,000-volt lines, where rubber gloves are used. The sharp corners on the threads of one of the U-bolt-type connectors are apparently not injurious to rubber gloves. Although the installation of the U-bolt-type connector with rubber gloves, is a bit awkward, there seems to be very little complaint from the field. One party reported a possible hazard when installing two-part connectors to a tap, as a result of the man getting in series with the tap and lines.

On lines of 6,900 to 16,000 volts, only the vise type of connector has been used to any extent. Tests with a newly

developed tool (see Fig. 3) for installing the vise-type and one make of U-bolt-type connector, indicate that the vise-type connector is best adapted for live-line work, with the tools available at this time.

There are no live-line tools available on the market at this time for installing the wedge-type connector.

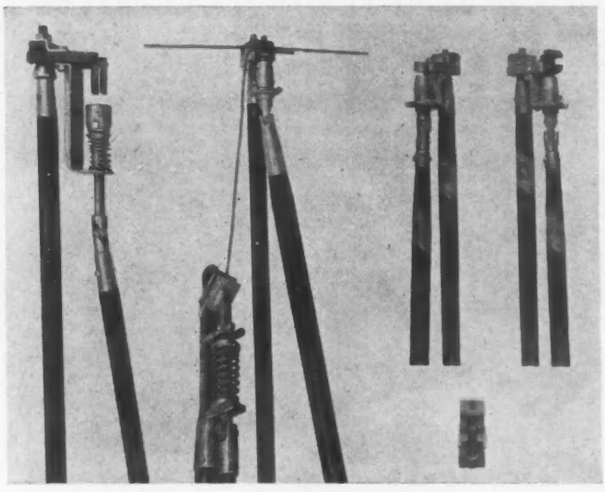

Fig. 4—Live-line tools for installing solderless connectors

Tools for Installing Solderless Connectors

Figs. 3 and 4 show several patented tools for installing solderless connectors. Reports from the field show that only the tool shown on Fig. 4 is used to any extent for installing connectors on energized lines of 6,900 to 16,000 volts.

On low-voltage and "dead" circuits the usual wrench and screwdriver are used.

Application

Replies from the six electric utilities in California reveal the following facts:

1. Five companies use solderless connectors when tapping secondary services to house outlets, mostly on the smaller-sized conductors ranging from No. 8 to 1/0.
2. All six companies use them in tapping services to secondary circuit on poles of all sizes; however mostly on the smaller sizes ranging from No. 8 to 2/0.
3. Only four companies use them on secondary transformer taps and for secondary connections on taps and corners of pole lines, in the small sizes of conductors.
4. Application to transformer connections, taps and connections on 2,300 to 4,000-volt lines, is answered in (3) above.
5. Only two companies use them on transformer connection, taps and connection on 6,900 to 11,500-volt lines in the small size conductors.
6. Three companies install them on energized lines of 2,300 to 4,000 volts, with rubber gloves.
7. Only one company is installing them on energized lines of 6,900 to 16,000 volts with a live-line tool. The vise-type connector is used for this purpose.
8. Six companies use the U-bolt type of connector, of which three use bronze and three use brass.
9. One company uses the clamp-type connector on the small-sized conductors.
10. One company uses the vise type on large conductors in low-voltage circuits and on all sizes when installed on high-voltage energized circuits.
11. None reported the use of the wedge-type connector.

Cost of Connectors

It is not intended to give detail costs on all types of connectors in this report. Generally speaking, they can be summarized as follows:

The U-bolt type, made of brass, costs less, particularly for the smaller sizes. When made of bronze or hard copper, they compare with the wedge and vise types. The wedge type compares with the U-bolt (brass) type in the small sizes, are higher in the intermediate sizes, and less in the large sizes.

The vise type is more expensive in the small sizes, but cheaper in the larger sizes.

Cost of Solderless Wire Splices Versus Solderless Connectors

The exact cost of splices is a very hard item to figure, and is not readily available.

One connector company, however, has worked up cost data, which they claim show that the cost of a connector installed and taped complete on a No. 2 copper wire, is 52 per cent of a soldered tap connection.

Conclusion

U-bolt-type connectors in brass and bronze metals are most widely used and best adapted for secondary and unenergized lines, on all sizes of conductors. The brass connectors are considerably cheaper than those made of bronze. The bronze are economical in the smaller sizes, but very expensive in the large sizes.

Vise-type connectors in silicon alloy are most used for hot-line work and are economically used on the intermediate sizes of conductor for all voltages.

The wedge type has not been used. It has good features, such as high conductivity and high tensile holding power. Due to lack of a proper tool, it is not adapted to hot-line work. Economically it is best suited for the small and large sizes of conductors.

There is still a need for an improved connector and/or a tool for installing connections on energized high-voltage circuits.*

* The writer is indebted to J. B. Madden and A. D. McIntyre for the information received on the testing of connectors.

Appendix

Miscellaneous Solderless Connectors for Connecting Wires to Ground Rods

Ground Clamps:

A very interesting method of making a solderless connection to a ground rod has been developed by a southern California utility.

This is a universal clamp, as it can be used on all sizes of pipe from 1 in. in diameter up. It is different from other ground clamps in that the ground wire is clamped around the pipe, making a direct connection to the pipe, thus providing a direct path for the ground current and making an extremely low resistance ground possible. Other ground clamps carry all or part of the ground current, but this new clamp carries none.

The following is part of a report made on this clamp as tested by the utility's laboratory:

The clamp was placed on a 6-in. pipe using No. 1 stranded wire. A coating of No. 3971 primer, a product of the Paraffine Co., was allowed to remain on the pipe when the clamp was installed. The The contact resistance between the wire and the pipe was found to be 0.0000182 ohms.

After the resistance was measured, a current of 3,000 amp. was put through the connection, and although the wire leading to the clamp became red dhot, there was comparatively little heat at the contact between the wire and the pipe.

*Conductor Vibration**

A discussion of the present knowledge in regard to conductor vibration and the studies now under way.

THE cause of many puzzling conductor failures in the past has in recent years been found to be conductor vibration. Since its recognition, engineers have diligently studied its characteristics in an endeavor to alleviate or entirely prevent conductor damage from this source.

* Report prepared by H. H. Shields for the subcommittee on line conductors, overhead systems committee.

Theory of Resonant Vibration

The generally accepted theory of conductor vibration is that air currents across the line produce eddies on the leeward side of the conductor. These eddies form periodically above and below the center of the conductor and create a rapidly alternating condensation and rarefaction. When this condition exists quite uniformly over the entire span, the conductor gets in step with the eddy frequency and a sinusoidal harmonic vibration ensues. Once started, the amount of energy required to maintain vibration is extremely small and it will persist until a slight change in wind condition occurs.

Factors Affecting Vibration

The air currents must be steady and any disturbance, whether caused by trees or buildings close to the line, rough country, or heat waves, is generally sufficient to prevent vibration. This is the reason vibration is most often found in flat open country where the prevailing direction of the wind is across the line and in the night or early morning hours when the air is not disturbed by heat.

Armed with this fact, one utility attempted to stop vibration by breaking up the conductor symmetry. One span in a tower line was lowered and a No. 4 solid aluminum wire was wound around the 605,000-circ.mil ACSR conductor in a 6-ft. spiral for 300 ft. near the center of the span. An appreciable reduction of the vibration was noted. The method, if carried out for the full length of the span, might have proved effective, but the matter was dropped, as the method was not considered practical.

Vibration is a strictly mechanical problem. It is no different when the line is energized than when it is unenergized, regardless of the operating voltage.

The conductors vibrate only in a vertical plane. Reported frequencies vary from 5 to 52 cycles per second, nodes 4 to 40 ft. in length, and amplitudes from 1/32 in. to 1 in. Amplitude is defined as the vertical motion of a point on the conductor at the center of the node or loop.

Vibration occurs with steady winds of low or moderate velocity only, and is most vigorous for barely perceptible air current of two or three miles per hour. Large-diameter cables may vibrate in winds up to twenty miles per hour, but generally all visible vibration ceases when the velocity exceeds twelve to fifteen miles. Vibration sometimes occurs with the wind at as low an angle as ten degrees to the line, but ordinarily is not in evidence until the angle exceeds thirty degrees.

Conductors of light-weight material appear to vibrate more readily and frequently than those of heavier-weight materials. There is apparently a relationship between the tendency to vibrate and the ratio of the weight of the conductor to its diameter. The smaller this ratio, the greater the tendency to vibrate. Experience of the Pacific Coast utilities indicates the truth of this statement, as, with a few exceptions, all trouble has been on aluminum or ACSR lines. One case of trouble has been reported on a No. 2 hard-drawn solid copper 70-kv. line. It has also been recently observed, during a period of favorable wind, that a 500,000-circ.mil hollow copper conductor was vibrating considerably. However, as far as is known at present, no material trouble has developed in copper conductors due to vibration.

For a given conductor material, small sizes tend to vibrate more than large sizes.

As the tension of a conductor increases, so does the frequency and amplitude of vibration, the wind velocity remaining constant. However, conductors strung at any economically feasible tension will still vibrate, so low conductor tensions are not a solution of the problem.

When conductors fail due to vibration, the break usually occurs at the points of attachment, that is, at the suspension or deadend clamps. At these points, the wires are subjected to appreciably more bending than at other portions of the span. The clamp, weighing more than an equal length of conductor, has a higher moment of inertia and movements of the wire result in the wire being rather sharply bent at the lip of the clamp, the effect being practically the same as where wire is held in a vise and bent back and forth until failure occurs. The manufacturers have recognized this fact and their modern clamps have moments of inertia of only 1/10 to 1/5 of the older clamps. However, when an arcing shield is attached to the clamp, the moment of inertia is greatly increased and we are back again where we started.

The flexibility of a conductor apparently has some bearing on vibration. One span of 397,000-circ.mil all-aluminum cable was given a coat of P&B paint. The vibration of this and an adjacent span was measured. When the paint was first applied, no effect was noticeable, but after it had become dried and the cable stiffened, the lessening of vibration was very pronounced.

Methods of Measuring Vibration

Vibration records are taken on smoked, circular charts, by a Bristol meter connected to the wire by a waxed string, as shown in Fig. 1. A wind vane and anemometer are attached, and the chart shows amplitude of vibration, hours of occurrence and duration, wind velocity and direction.

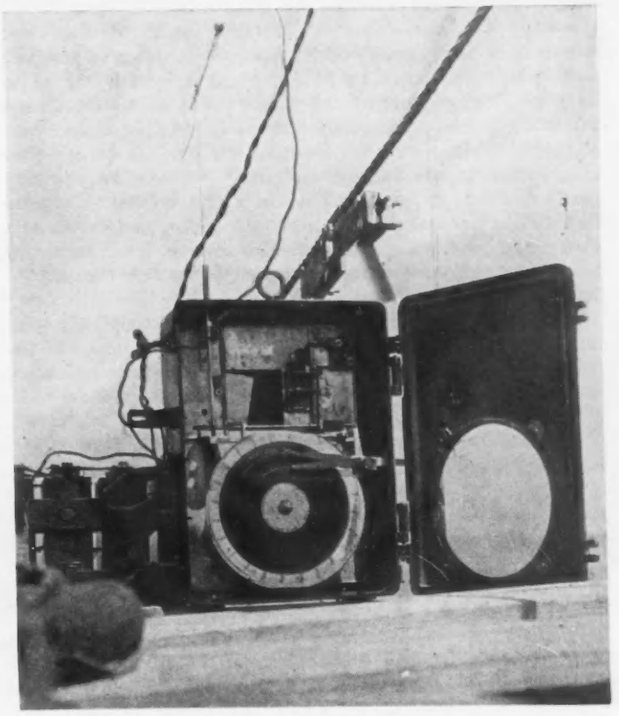

Fig. 1—Instrument mounted on platform under wire on experimental spare. Anemometer was mounted on point of steel arm and connected to instrument by twisted pair shown in picture

Preventing Vibration Damage

The methods of preventing vibration damage to lines may be divided into two classes:

1. To protect the conductor.
2. To suppress or prevent vibration.

The earliest attempts at a solution of the vibration problem fall into the first class. Several devices have been used

with varying degrees of success. One of the earliest methods was to attach a short length of cable to the conductor, extending a few feet out from the support. Only in a few cases, however, has this method been successful. An improvement of the stiffening cable is afforded by using armor rods. They consist of a layer of small rods spiraled around the conductor for a short distance out from the point of support. For all but the smaller sizes of cable, the rods are tapered at each end to form a more gradual change in the stiffness of the cable as it approaches the clamp. Laboratory tests on 120-ft. spans, mechanically vibrated at higher tensions and greater amplitudes than usually occur on actual lines, have demonstrated that armor rods will prolong the life of a conductor under such extreme conditions from 40 times to an indefinite extent.

Stockbridge Vibration Damper

The Stockbridge damper falls in the second class, and although it was developed six or seven years ago, its principle of operation is not fully understood even today. One theory that has been advanced is that the energy in the conductor vibration impulses is absorbed by friction and hysteresis in the short messenger cable supporting the two weights. Another theory is that the damper sets up a vibration at, or nearly, 180 deg. out of phase with the conductor vibration, the result being complete, or nearly so, nullification of vibration at the supporting clamp. At the present time the weight of the damper, the size and kind of messenger cable, and the position of attachment to the conductor are determined by experiment. The Southern California Edison Company have these dampers installed on all of their lines where they have experienced vibration trouble. A satisfactory design for small sizes of cable, however, is yet to be developed. Engineers of the Coast utilities and the manufacturers are experimenting and studying this damper and undoubtedly they will develop dampers for use on all sizes of conductors. In this connection, it is interesting to note that engineers of the San Joaquin Light & Power Corporation and engineers of the manufacturing companies working in Texas, have both independently developed a damper of practically the same weight and dimensions for use on 266,-800-circ.mil all-aluminum conductors.

It is felt that vibration damage can be completely controlled and prevented. There can be found a damper of the proper weight and dimensions for each case. It is necessary only to suppress the natural or ordinary loop which corresponds to the natural periodicity of the span. This occurs 90 per cent of the time. Other vibrations are infrequent and have small effect, especially low-frequency long-loop vibration.

The dampers should have a lead shim between the messenger cable and the weights in order to withstand the effect of high-frequency vibration. The messenger cable should be of high-strength guy strand to give long life and to prevent drooping from the effect of long waves.

From one to three dampers are required per span, the number depending upon the severity of the vibration in each span, which in turn depends upon the span length. The first damper should generally be placed at the middle of the first natural or ordinary node or loop, but always inside the shortest high-frequency loop to be observed.

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*Splices and Sleeves**

A discussion of the present types of sleeves and connectors available and of the characteristics which are necessary to make up the ideal joint.

* Report prepared for the subcommittee on line conductors, overhead systems committee, Engineering Section.

THE methods of joining the two ends of a line conductor together may be divided into two general classes, namely splices and mechanical connectors or sleeves.

Splices

Splices may be further subdivided into:

(a) Western Union splice.
(b) Three-wire splice.
(c) Three-collar two-wire splice.
(d) Dovetail splice.
(e) Side splice.

The Western Union splice is made by laying the ends of the wires side by side and twisting together for three or four long twists and then "pigtailing" or closely wrapping the ends three or four times around the other wire.

The three-wire splice is made up in the same manner as the Western Union splice, except that a third piece of wire is twisted into the splice. This is a stronger splice than the Western Union splice, but neither splice is as strong as the wire.

Both of these splices are adaptable only to the smaller sizes of solid, ductile wire. The bending of a wire cold sets up internal stresses in the wire, which, of course, weaken it mechanically and the higher the temper of the wire, the greater are these internal stresses.

Solder is often used in making up these splices to increase their conductivity. Extreme care is necessary in soldering splices in hard or medium-hard-drawn copper wire, or else the tensile strength of the splice will very likely be no greater than if the conductors were soft-drawn copper.

Some of the causes of failure of these splices may be listed as follows:

(a) Burning of wire at point of serve-up, due to being improperly made.
(b) Burning with connectors.
(c) Nicking with tools.
(d) Too short a splice or an insufficient number of turns of each wire.
(e) Too many turns, causing burning.
(f) Splice not tight enough, resulting in slipping.
(g) Annealing from hot solder or torch.
(h) Too tight a twist.

The dovetail splice is used on stranded conductors and is made by fitting the strands of one cable between those of the other and wrapping one strand at a time around the others and around the cable.

Very few failures of this splice have been reported when it is used on copper conductors. The failures reported have been caused by:

(a) Insufficient length of splice.
(b) Poor workmanship.
(c) Unequal strain on various individual strands.
(d) Failure to "lock" individual strands when used on heavy cable. "Locking" consists of a half hitch of one strand over the other and is used principally on heavy cables.

When this dovetail splice is used on aluminum conductors, it often fails, due to corrosion.

Another splice used on stranded conductors is the side splice. This splice is made by placing the cables beside each other and serving up each strand. The tensile strength of this splice is less than that of the dovetail splice and neither splice is as strong as the cables, due to the internal stresses set up in each strand caused by bending when cold.

A great deal of time is required in making both of the above splices, which of course makes them quite costly.

Sleeves or Mechanical Connectors

There are quite a number of mechanical connectors or sleeves on the market. Reasons for using them instead of splices may be summarized as follows:

MECHANICAL TESTS OF CONDUCTOR SPLICES
A. B. C. SLEEVE, TYPE M
DECEMBER 21 AND 22, 1931

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)									
		SPECIFICATIONS										TEST OF SPLICE								
		Machine Rolls			Hard Drawn Copper Tubing		CONNECTOR											Per cent Ultimate Tension		
Size of Wire	H. D. Copper	O. D. in.	Groove Diam. (A) in.	Centers in.	O. D. in.	I. D. in.	Diam. Helix Cutter in.	Pitch of Helix in.	Depth Helical Cut in.	O. D. at End (B) in.	Length in.	Length of Finished Splice in.	Tension at Initial Stretch (C) lb.	Maximum Stretch Before Failure (C) in.	Point of Failure (D)	Tension at Failure (D) lb.	Ultimate Tension of Wire			
																	G.O.64A lb.	By Test lb.	G.O.64A	Conductor
8	Solid	2.625	2.425	2.625	0.250	0.131	0.625	0.250	0.014	9/16	4	4 1/4	750	1/4	28-in. from sp.	810	780	810	103.8	100.0(E)
8	Solid	2.625	2.425	2.625	0.250	0.131	0.625	0.250	0.014	9/16	4	4 1/2		1/4	1/2-in. in sl.	800	780	810	102.6	100.0(E)
8	Solid	2.625	2.425	2.625	0.250	0.131	0.625	0.250	0.014	9/16	4	4 1/2	790	1/4	1/2-in. in sl.	810	780	810	103.8	100.0(E)
8	Solid	2.625	2.425	2.625	0.250	0.131	0.625	0.250	0.014	9/16	4	4 1/2	2,020	1/4	1/2-in. in sl.	2,090	2,125	2,120	98.4	98.6
6	Strd.	6.5	6.166	6.5	0.375	0.237	0.500	0.500	0.021	9/16	7	7 5/8	2,080	1/8	5/8-in. in sl.	2,080	2,125	2,120	98.1	98.1
6	Strd.	6.5	6.166	6.5	0.375	0.237	0.500	0.500	0.021	9/16	7	7 5/8	2,080	1/8	5/8-in. in sl.	2,105	2,125	2,120	99.3	99.3
4	Strd.	6.5	6.166	6.5	0.375	0.237	0.500	0.500	0.021	9/16	7	7 5/8	1,900	1/4	5/8-in. in sl.	3,050	3,045	3,090	100.2	98.7
4	Strd.	6.5	6.050	6.5	0.500	0.299	0.500	0.500	0.025	11/16	8	8 1/8	3,000	1/4	5/8-in. in sl.	3,050	3,045	3,090	100.2	98.7
2	Strd.	6.5	6.050	6.5	0.500	0.299	0.500	0.500	0.025	11/16	8	8 1/8	2,930	1/4	7/8-in. in sl.	3,090	3,045	3,090	101.5	100.0
2	Strd.	6.5	6.050	6.5	0.500	0.299	0.500	0.500	0.025	11/16	8	8 1/8	5,550	1/4	1 1/8-in. in sl.	5,920	5,925	6,040	99.9	98.1
2/0	Strd.	6.5	5.891	6.5	0.675	0.430	0.750	0.750	0.030	13/16	12	12 13/16		1/4	7/8-in. in sl.	6,075	5,925	6,075	102.5	100.0
2/0	Strd.	6.5	5.891	6.5	0.675	0.430	0.750	0.750	0.030	13/16	12	12 13/16	5,930	1/4	1 -in. in sl.	6,010	5,925	6,040	101.4	99.5
2/0	Strd.	6.5	5.891	6.5	0.675	0.430	0.750	0.750	0.030	13/16	12	12 13/16	5,100	1/4	3/4-in. in sl.	6,030	5,925	6,040	101.8	99.8
2/0	Strd.	6.5	5.891	6.5	0.675	0.430	0.750	0.750	0.030	13/16	12	9		1/4	In wire outside sleeve					
4/0	Strd.	6.5	5.742	6.5	0.840	0.546	0.750	0.750	0.040	15/16	14	14 3/4	8,500	1/8		9,190	9,155	9,190	100.4	100.0
4/0	Strd.	6.5	5.742	6.5	0.840	0.546	0.750	0.750	0.040	15/16	14	14 3/4	9,100	1/4	1 1/8-in. in sl.	9,170	9,155	9,190	100.2	99.8
4/0	Strd.	6.5	5.742	6.5	0.840	0.546	0.750	0.750	0.040	15/16	14	14 3/4	9,140	1/4	1 -in. in sl.	9,240	9,155	9,240	100.9	100.0
4/0	Strd.	6.5	5.742	6.5	0.840	0.546	0.750	0.750	0.040	15/16	10	10 1/2	8,000	1/8	3/4-in. in sl.	9,170	9,155	9,190	100.2	99.8

Notes:—
(A) At bottom of groove. For details see Drgs. R-S-19-A and R-S-27-B.
(B) Ends are beveled 5 deg. to these outside diameters.
(C) Lengthening of conductor inside of sleeve.
(D) In all tests conductor failed inside or outside of sleeve, and did not slip out of sleeve.
(E) Indicated valve—no separate test made of wire.

sp. —splice
sl. —sleeve

(a) Greater mechanical strength.
(b) Neater job.
(c) Joint can be made quicker and more easily.
(d) More uniform appearance.
(e) Less corrosion, except in very corrosive atmosphere, with resultant better conductivity.
(f) Less likelihood of damaging the wire.
(g) More consistent results in the hands of various workmen.
(h) Less expensive splice.
(i) Heat or solder is not required in making the splice.

Sleeves appear to be in quite general use on all circuits except the higher-voltage transmission lines. The causes of conductor failure at these joints have been reported as:

(a) Using wrong size of sleeves.
(b) Burning of wire, due to line not turning with connectors or wrench when splice is being made up.
(c) Damages to sleeves, due to connectors or other tools not fitting sleeves.
(d) Too many turns or twists. Three and one-half or four full turns seem to give the best results.
(e) Not enough turns or twists, with resultant creeping.
(f) Carelessness in the use of pliers in cutting and bending conductor ends back against the sleeve ends.
(g) If cable is not properly cleaned, arcing between strands may occur, with resultant corrosion, especially in a corrosive atmosphere.

Compression connectors or sleeves have been used for many years on important transmission lines. One reason why they have not been used more generally is probably the fact that special, bulky tools are required to compress the connector, but this disadvantage is outweighed in the case of important lines by the high tensile strength of the joint. At the present time certain manufacturers of connectors and sleeves claim that their product will produce a joint as strong as the conductor. Engineers of the California State Railroad Commission have recently witnessed tests of some of these connectors and we understand they will approve their use in grade "A" construction in specific cases. Representatives of one manufacturer are preparing at the present time to test all sizes of their product before the commission's engineers.

Utilities' Experience With Connectors

One utility reports that a compressed type of splice was used on a 4/0 ACSR conductor on a tower line built in 1912. This splice consists of a special two-part aluminum sleeve connector. A McIntyre sleeve of soft steel was used for joining the ends of the steel core. The two sections of the aluminum sleeve having been slipped back over the cable before joining the ends of the steel core, were next screwed together and the ends of the aluminum connectors were compressed by a small portable hydraulic jack. In this manner the strength of both the steel and the aluminum is developed and the conductivity of the joint as a whole is somewhat greater than that of an equal length of cable. This type of splice has not proven altogether satisfactory in all cases. Experience has indicated that moisture gathers on the ungalvanized sleeve inside of the aluminum sleeve. The corrosion caused by this moisture has been the cause of several failures. All recent splices on this line have been made with the ordinary aluminum sleeve with stranded conductor served up at either end.

On the Pit-Vaca 220-kv. line of the Pacific Gas and Electric Co. a field connector is used to join the conductors which are 500,000-circ.mil rope-strand copper cable. This connector consists of a hollow round body casting 11½ in. long and 3 7/16 in. in diameter with a sliding cylindrical cover in the center. This casting is tapered on both ends, the center section being cylindrical for a distance of 3½ in. The sliding cover fits over this section. In the tapered ends, wedges are used. These are tapering and grooved and are split into three parts. The conductor, consisting of seven strands of seven wires each, is carefully spread into seven strands, the center strand passing through a groove in the center of the wedges and the other six strands being spread into grooves

around the circumference of the wedges. The strands are held in place by bending square over the wedges at least one wire of each strand. The wedges are held in place by set screws which are tightened after the conductor is under tension. The sliding cover is then slid over the connector and crimped down on each end to hold it in place. This makes a very good joint.

THE IDEAL JOINT

The requirements of an ideal joint are:

1. It should be as strong as the conductor.
2. Its conductivity should be equal or better than that of an equal length of conductor.
3. It should be non-corrosive in order that its conductivity and mechanical strength will not be impaired with the passage of time.
4. Preferably, no special tools should be required to make the joint, but, if necessary, they should be simple, light and compact.
5. It should meet the Railroad Commission's strength requirements for all grade "A" construction.
6. Its cost must compare favorably with the present costs of making joints.

The first requirement eliminates splices, because no splice is as strong as the conductor. The solution of the problem, therefore, lies in some type of sleeve or mechanical connector. New connectors of merit are being introduced from time to time, showing that the manufacturers recognize our problem and we have entire confidence in their ability to solve it to the satisfaction of all concerned.

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*Pole Line Structures**

The work of the subcommittee on pole line structures was divided between two committees. One committee with E. M. Wright as chairman, made a study of guying; the other committee, with Ralph E. Hill as chairman made a study of methods of inspecting poles in service.

The committee on guying handled its subject from the approach: Are the guying requirements of General Order No. 64A of the Railroad Commission of California too severe, and if so what changes are warranted? The committee has arrived at the conclusion that present requirements of the above-referred-to order are too severe and should be reduced. The committee's report describes its investigation, contains its conclusions, and makes definite recommendations.

The committee on methods of inspecting poles in service outlines in its report what a pole inspection program should include and how a pole inspection should be made. The subject of inspection of poles before climbing is also touched upon.

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* Report of subcommittee on pole line structures, overhead systems committee, Engineering Section. Paul Suransky, chairman. E. R. Banks, R. C. Barton, F. D. Beardsley, C. A. Bennett, W. P. Champion, Clinton DeWitt, A. R. Fryklund, R. V. Guilbault, C. St. John Hale, W. T. Hannum, Ralph E. Hill, A. M. Jeppeson, H. E. Jung, C. W. Lightner, W. B. Loper, J. E. McDonald, C. C. Mattson, C. T. Mess, H. Michener, R. H. Taber, C. P. Taylor, L. F. Theis, E. M. Wright, C. L. Yager.

*Safety Factor on Guys**

The subcommittee on guying was given the specific problem of investigating the safety factor on guys, to determine if the requirements of General Order 64A are too stringent, and, if so, to recommend a definite modification of the rules.

A complete record of all committee discussions and the calculations cannot be given in this report but the final analysis, together with some field data are presented with the intention of showing that a guy, installed with a safety factor of 1.5 for maximum conditions, is sufficient for all conditions of conductor tensions and span length.

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* Report of subcommittee on guying, line conductors subcommittee, overhead systems committee, Engineering Section. E. M. Wright, chairman. E. R. Banks, F. D. Beardsley, C. St. J. Hale, W. T. Hannum, H. E. Jung, W. B. Loper, C. C. Mattson, C. T. Mess, R. H. Taber.

MANY factors have entered into the guying question during the last ten years, some of which are enumerated in the following discussion.

Overhead construction has become much heavier due to a number of factors, such as: increased load, necessitating more circuits or heavier conductors; the use of higher poles to give the specified clearances and safety over trees, buildings, etc.; and the extension of joint-pole construction. This has automatically increased the required strength of guys to the point where almost all the companies have been forced to the use of high-strength material for the guy strand. Due to the stiffness of this high-strength guy strand, it is highly desirable to use the smaller sizes, those from ½ in. down. Any reduction in strength required of the installation will be directly instrumental in reducing the number of guys necessary. There is every evidence that conductor tensions decrease immediately after stringing and reports from member companies call attention to this fact and point out that tensions have been decreased, due to setting of the deadend clamps, guy clamps, anchors, stranded conductor, etc. Many cases were found where sag was twice as much as when originally strung. The fact that every slip, set, or change in the original conditions in the line tends to decrease the tension in the conductor and therefore to decrease the tension in the guy, is a vital factor in the consideration of the initial safety factor.

The manufacturers of guy wire under the present conditions have set minimum strengths for the grades of material used, but cannot economically work very close to these minimums. The tolerances asked by the manufacturer are from 10 to 30 per cent above the minimum, in fact they reach to the next grade above. This in general gives a strength in the guy above that used in the calculation.

All material for a guy installation is chosen in steps. If it is necessary to furnish a single guy for a 2,500-lb. installation, the size of wire used might have a strength of 5,000 lb. (the next lower being 2,000), thus making the wire 100 per cent stronger than necessary. If a safety factor of 1.5 is being used, this would be increased to 3.0. In general all installations would be above the safety factor used in the calculations.

Each and every one of the above points adds to the reserve strength of the guy installation over and above that due to the safety factor used.

One member company has submitted a cost comparison of one year's installation of guys (not including new construction on long high-tension lines) showing a comparison of old installations with new installations. The old installations were put in before G. O. 64 became effective and about 75 per cent are still in operation. Based on the year 1930 installation, the company would have saved $120,000 if the old installations had been put in. With a total cost to this company of $450,000 per year for guying under the existing ruling, it is estimated that a minimum of $50,000 would be saved by reducing the safety factor from 2 to 1.5. Tables I and II show the difference in unit guy costs for old and new practices. These tables were used by the above company in calculating the above mentioned savings.

Although the elastic limits of guy wire and anchor rods have but little to do with the safety factors on the ultimate strength, these were taken seriously into consideration in arriving at the final recommended figure. Assuming a safety factor of 1 on the elastic limit of the guy at maximum loading conditions, the safety factor based on the ultimate would then be 1.33, which would be enough to prevent ex-

ceeding the elastic limit under the maximum loading conditions, even though the elastic limit be taken as low as 75 per cent of the ultimate. By accepting a safety factor above this, namely 1.5, the safety of the guy is assured.

TABLE I

Comparison of Unit Cost of Guys When Constructed According to Old Practice and When Constructed According to C. R. C. General Order No. 64A September, 1931

	Old Standards		Order No. 64A Requirements					
			Arm Guy		Head Guys			
	Head Guy		Under 2,000-lb.		3,000-lb. Strain		7,500-lb. Strain	
	Wgt.	Amount	Wgt.	Amount	Wgt.	Amount	Wgt.	Amount
Based on 125-ft. Avg. Length								
125-ft. ¼-in. Com. Guy Strand	19	0.96	19.0	0.96	....	....	....	....
125-ft. ⅜-in. H. S. Guy Strand	..	....	....	....	25.5	2.16	....	....
125-ft. ½-in. H. S. Guy Strand	..	....	....	....	....	....	50.0	5.00
2 No. 504 Breakers	2	0.34	2.0	0.34	2.0	0.34	....	....
2 No. 532 Breakers	..	....	....	....	....	....	5.0	0.82
3 Guy Plates	..	....	2.5	0.28	....	....	....	....
6 Guy Plates	1	0.31	....	....	5.0	0.55	5.0	0.55
6 3-Bolt Clamps	11	1.50	11.0	1.50	....	....	....	....
12 3-Bolt Clamps	..	....	....	....	22.0	3.00	....	....
18 3-Bolt Clamps	..	....	....	....	....	....	33.0	4.50
2 ½ x 4-in. Lags	..	....	0.5	0.05	....	....	....	....
4 ½ x 4-in. Lags	1	0.10	....	....	1.0	0.10	1.0	0.10
Nails, Nuts, etc.	..	0.01	1.0	0.25	....	0.01	....	0.01
Frt. to Zone III, Cl. 4, LCL at 0.218 cwt.	34	0.07	36.0	0.08	55.5	0.12	94.0	0.21
Subtotal		3.29		3.46		6.28		11.19
Store Expense 7%		0.23		0.24		0.44		0.78
Labor		2.00		2.00		2.50		3.00
T. & T. Exp. 15% of labor		0.30		0.30		0.37		0.45
Total		5.82		6.00		9.59		15.42

In order to determine the condition of old guys, a number of field inspections were made by several of the member companies. Instead of obtaining the conductor tensions, etc., in all cases it was found that the maximum tensions on the guys were to all intents and purposes not more than 1.4 times the tensions at 60 deg. for all sizes and tensions of bare copper conductors and for lengths of span above 264 ft. Table III shows the values obtained for various sizes of bare conductor.

Table IV shows a list of examples of field conditions on existing guys installed in general before G. O. 64A became effective. These lists, taken at random, were not intended to show flagrant overstresses, but do show that although guys have in some cases safety factors less than 1, they have been in operation for as long as 15 years without failure, and in addition are probably stressed lower than when they were installed. No field data was taken on guys installed according to G. O. 64A.

In view of the fact that a safety factor of 1.5 is in itself sufficient to maintain a safe installation, that there are many factors each contributing an additional strength to the installation, that many guys having a safety factor of 1 or less have been in operation for 10 or more years without failure, and that we as a committee have been unable to find any record of guy failures among the member companies, we as a committee recommend that application be made to the Railroad Commission of California to amend G. O. 64A, permitting the use of a factor of safety of 1.5 instead of 2 as at present prescribed. We are therefore submitting a resolution to the overhead systems committee whereby this application may be formally made. This resolution was passed by the executive committee of the Engineering Section and will be taken up with the Railroad Commission of California for suitable action.

TABLE III

Initial Unit Tension lb. per sq. in.	Final Tension—Initial Tension		
	No. 2 Cu.	No. 2/0 Cu.	No. 4/0 Cu.
5,000	1.44	1.30	1.22
6,000	1.46	1.31	1.26
7,000	1.47	1.34	1.28
8,000	1.47	1.35	1.30
9,000	1.44	1.35	1.30
10,000	1.44	1.35	1.31
11,000	1.41	1.35	1.31
12,000	1.39	1.34	1.30
13,000	1.37	1.34	1.30
14,000	1.36	1.33	1.30
16,000	1.32	1.32	1.27
18,000	1.29	1.29	1.26
20,000	1.26	1.27	1.26

Span assumed 264 ft.
Bare copper conductor.

The following questions were taken up for discussion and attention of the guying committee for the next year:

1. Standardization of the minimum requirements for strength of guys. There are at present differences in minimum strengths as specified by G.O. 64A and those recommended by the manufacturer. A resolution was passed by the overhead systems committee and the Engineering Section executive committee to ask the Railroad Commission of California to revise General Order 64A, Table 22, to agree with the accepted manufacturer's list.
2. Identification of guy strengths. Some companies are having the guy strands marked so that they may be identified in the field. This is done by the manufacturer in stranding.

TABLE II

COMPARISON OF COSTS OF ANCHOR GUYS WHEN CONSTRUCTED ACCORDING TO OLD COMPANY PRACTICE AND WHEN CONSTRUCTED ACCORDING TO C. R. C. GENERAL ORDER NO. 64A

	Old Co. Practice Patent Anchor and Guy			Order No. 64A Requirements											
				3,000-lb. to 7,500-lb. Strain			10,000 lb. Strain			15,000-lb. Strain			20,000-lb. Strain		
	Unit ft.	Wt. lb.	Amount $	Unit ft.	Wt. lb.	Amount $	Unit ft.	Wt. lb.	Amount $	Unit ft.	Wt. lb.	Amount $	Unit ft.	Wt. lb.	Amount $
Based on 40-ft. Poles:															
¼-in. Com. Guy Wire	50	15.0	0.68	...	....	....	...	....	....	...	....	....	...	....	....
⅜-in. H. S. Guy Wire	...	....	....	50	14.8	1.47	100	29.6	2.93	...	....	....	...	....	....
½-in. H. S. Guy Wire	...	....	....	...	....	....	...	....	....	100	40	4.00	125	50.0	5.00
No. 504 Breakers	1	1.3	0.17	1	1.3	.17	...	....	....	...	....	....	...	....	....
No. 532 Breakers	...	....	....	...	....	....	2	4.8	0.82	...	....	....	...	....	....
No. 534 Breakers	...	....	....	...	....	....	...	....	....	2	12	1.09	3	18.0	1.63
6-in. 3-bolt Clamps	4	9.0	1.00	8	18.1	2.00	16	36.2	4.00	24	54	6.00	36	81.0	9.00
Guy Plates	3	1.0	0.17	3	2.5	.28	6	5.0	0.55	6	5	0.55	9	8.0	0.83
Nails	...	....	0.01	...	....	0.01	...	....	0.02	...	....	0.02	...	....	0.03
Lags, ½-in x 4-in.	2	0.5	0.05	2	0.5	0.05	4	1.0	0.10	4	1	0.10	6	1.5	0.16
Guy Thimble	...	....	0.05	...	....	0.05	...	....	0.05	...	....	0.10	...	....	....
3-way Guy Attachment	...	....	....	...	....	....	...	....	....	...	....	....	1	3.0	0.64
Anchor, Nevercreep 6 x 20	1	10.0	1.44	...	....	....	...	....	....	...	....	....	...	....	....
Code 1940	...	....	....	1	9.3	1.44	...	....	....	...	....	....	...	....	....
Code 1912	...	....	....	...	....	....	1	15.0	1.79	...	....	....	...	....	....
10-in. Chance 4-way	...	....	....	...	....	....	...	....	....	1	26	3.00	...	....	....
Treated Slug at Local Whse.	...	....	....	...	....	....	...	....	....	...	....	....	...	....	3.42
4 x 4-in. washer	...	....	....	...	....	....	...	....	....	...	....	....	...	....	0.06
Anchor Rods	1	13.0	0.85	1	13.0	0.85	1	29.0	2.09	1	29	2.09	1	29.0	2.09
Steel Guy Guard	1	15.0	1.82	1	15.0	1.82	1	15.0	1.82	1	15	1.82	...	....	....
Hubbard No. 7569 Guy Guard	...	....	....	...	....	....	...	....	....	...	....	....	1	32.0	3.75
Frt. to Zone III C14 LCL. at .218	...	65.	0.14	...	74.	0.16	...	136.	0.30	...	182	0.39	...	223.	0.49
Subtotal			$6.38			$8.30			$14.47			$19.16			$26.60
Store Expense 7%			0.44			0.58			1.01			1.34			1.86
Labor			2.75			3.50			6.00			7.00			10.00
T. & T. Expense, 15% of labor			0.40			0.53			0 90			1.05			1.50
TOTAL			$9.97			$12.91			$22.38			$28.55			$39.96

TABLE IV

Test No.	Type Guy	Size	Cond.	Existing Tension	Calc. Max. Tension	Ult. of Guy	Safety Factor Single Guy	Safety Factor Total Installation	Date Set
1	Com.	3/8	2/0 BC	2,400	3,360	4,250	1.27	1.38	1915
	Com.	3/8	2/0 BC	2,000	2,800	4,250	1.52	....	....
2	Com.	3/8	2/0 BC	2,600	3,640	4,250	1.17	1.41	1915
	Com.	3/8	.....	1,700	2,380	4,250	1.79	....	....
3	Com.	3/8	2/0 BC	1,400	1,960	4,250	2.17	1.84	1915
	Com.	3/8	2/0 BC	1,900	2,660	4,250	1.60	....	....
4	Com.	1/2	2/0 BC	1,750	2,450	3,200	1.30	1.30	1915
5	Com.	3/8	2/0 BC	2,200	3,080	4,250	1.38	1.73	1915
	Com.	3/8	.....	1,300	1,820	4,250	2.35	....	....
6	Com.	3/8	2/0 BC	1,750	2,450	4,250	1.73	1.73	1915
7	Com.	1/2	2/0 BC	1,500	2,100	3,250	1.52	1.52	1915
8	Com.	3/8	2/0 BC	2,300	3,220	4,250	1.32	1.32	1915
9	Com.	3/8	3/0 BC	1,200	1,680	4,250	2.53	0.98	1919
	Com.	1/2	3/0 BC	6,700	9,400	7,400	0.79	....	....
	Com.	1/2	3/0 BC	6,000	8,400	7,400	0.88	....	....
10	Com.	3/8	3/0 BC	2,600	3,640	7,400	2.03	1.67	1919
	Com.	1/2	3/0 BC	4,300	6,020	7,400	1.23	....	....
	Com.	3/8	3/0 BC	1,650	2,310	4,250	1.84	....	....
	Com.	3/8	3/0 BC	1,300	1,820	4,250	2.34	....	....
11	Com.	3/8	3/0 BC	2,000	2,800	4,250	1.52	1.52	1919
12	Com.	3/8	3/0 BC	2,400	3,360	4,250	1.27	1.57	1919
	Com.	3/8	3/0 BC	1,900	2,660	4,250	1.60	....	....
	Com.	3/8	3/0 BC	1,500	2,100	4,250	2.02	....	....
13	Com.	3/8	3/0 BC	2,200	3,080	4,250	1.38	1.53	1919
	Com.	3/8	3/0 BC	1,900	2,660	4,250	1.60	....	....
	Com.	3/8	3/0 BC	1,900	2,600	4,250	1.60	....	....
14	Com.	3/8	3/0 BC	3,100	4,250	4,250	1.00	1.00	1919
15	Com.	3/8	3/0 BC	2,300	3,220	4,250	1.32	1.32	1919
16	Com.	3/8	3/0 BC	2,000	2,800	4,250	1.52	2.02	1919
	Com.	3/8	3/0 BC	1,500	2,100	4,250	2.02	....	....
	Com.	3/8	3/0 BC	1,000	1,400	4,250	3.04	....	....
17	Com.	3/8	3/0 BC	2,100	2,940	4,250	1.44	1.72	1919
	Com.	3/8	3/0 BC	1,900	2,660	4,250	1.60	....	....
	Com.	3/8	3/0 BC	1,300	1,820	4,250	2.34	....	....
18	Com.	3/8	3/0 BC	2,600	3,640	4,250	1.17	1.17	....
19	Com.	3/8	3/0 BC	3,600	5,040	4,250	0.84	0.84	1919
20	Com.	3/8	6 BC	1,300	1,820	4,250	2.34	2.34	1921
21	Com.	3/8	6 BC	1,325	1,860	4,250	2.28	2.28	1921
22	Com.	3/8	6 BC	1,450	2,030	4,250	2.10	2.10	1921
23	Com.	3/8	6 BC	1,575	2,200	4,250	1.93	1.93	1921
24	Com.	3/8	6 BC	1,575	2,200	4,250	1.93	1.93	1921
25	Com.	3/8	6 BC	1,450	2,030	4,250	2.10	2.10	1917
26	Com.	3/8	6 BC	1,600	2,240	4,250	1.90	1.90	1917
27	Com.	3/8	6 BC	1,575	2,200	4,250	1.93	1.93	1921
28	Com.	3/8	6 BC	1,625	2,270	4,250	1.87	1.87	1919
29	Com.	3/8	6 BC	1,500	2,100	4,250	2.02	2.02	1920
30	Com.	3/8	3/0 Al.	2,100	2,940	4,250	1.45	1.45	1910
31	Com.	3/8	3/0 Al.	2,400	3,360	4,250	1.26	1.26	1910
32	Com.	3/8	3/0 Al.	1,850	2,590	4,250	1.64	2.29	1910
	.....	..	.....	800	1,120	4,250	3.80	....	1910
33	Com.	3/8	3/0 Al.	1,100	1,540	4,250	2.76	3.04	1916
	.....	..	.....	900	1,260	4,250	3.37	....	1919
34	Com.	3/8	4 BC	2,400	3,360	4,250	1.26	1.26	1921
35	Com.	3/8	2 BC	2,375	3,330	4,250	1.28	1.28	1921
36	Com.	3/8	4 BC	1,950	2,730	4,250	1.56	1.56	1921
37	Com.	3/8	4 BC	2,500	3,500	4,250	1.21	1.21	1921
38	Com.	3/8	4 BC	1,350	1,890	4,250	2.25	2.25	1921
39	Com.	3/8	4 BC	1,450	2,030	4,250	2.09	2.09	1921
40	Com.	3/8	4 BC	1,500	2,100	4,250	2.02	2.02	1921
41	Com.	3/8	4 BC	2,000	2,800	4,250	1.52	1.52	1921
42	Com.	3/8	4 BC	3,100	4,350	4,250	0.98	0.98	1921
43	Com.	3/8	4 WP	1,050	2,680	4,250	1.58	1.58	1916
44	Com.	3/8	4 WP	1,190	3,180	4,250	1.34	1.34	1916
45	Com.	3/8	4 WP	1,370	2,665	4,250	1.59	1.59	1918
46	Com.	3/8	6 WP	1,970	4,000	4,250	1.06	1.06	1922
47	Com.	3/8	4 WP	1,600	3,562	4,250	1.19	1.19	1922
48	Com.	3/8	2/0 BC	2,150	3,010	4,250	1.41	1.86	1915
	Com.	3/8	2/0 BC	2,400	3,370	4,250	1.26	....	....
	Com.	3/8	2/0 BC	350	490	4,250	8.67	....	....
49	Com.	3/8	2/0 BC	1,650	2,310	4,250	1.84	1.55	1915
	Com.	3/8	2/0 BC	1,850	2,600	4,250	1.63	....	....
	Com.	3/8	2/0 BC	2,350	3,300	4,250	1.29	....	....
50	Com.	3/8	2/0 BC	2,000	2,800	4,250	1.52	1.65	1915
	Com.	3/8	2/0 BC	1,600	2,240	4,250	1.90	....	....
	Com.	3/8	2/0 BC	1,900	2,660	4,250	1.60	....	....
51	Com.	3/8	2/0 BC	1,800	2,520	4,250	1.69	1.25	1915
	Com.	3/8	2/0 BC	2,000	2,800	4,250	1.52	....	....
	Com.	3/8	2/0 BC	3,500	4,900	4,250	1.87	....	....
52	Com.	3/8	2/0 BC	2,300	3,220	4,250	1.32	1.44	1915
	Com.	3/8	2/0 BC	1,900	2,660	4,250	1.60	....	....
	Com.	3/8	2/0 BC	2,100	2,950	4,250	1.44	....	....
53	Com.	3/8	2/0 BC	1,600	2,240	4,250	1.90	1.69	1915
	Com.	3/8	2/0 BC	2,000	2,800	4,250	1.52	....	....
	Com.	3/8	2/0 BC	1,800	2,520	4,250	1.69	....	....
54	Com.	3/8	2/0 BC	2,700	3,780	4,250	1.12	1.17	1915
	Com.	3/8	2/0 BC	2,500	3,500	4,250	1.22	....	....
55	Com.	3/8	4/0 BC	3,000	3,713	4,250	1.15	1.15	1918
56	Com.	1/2	4/0 BC	5,500	7,679	7,400	.96	.96	1918

Total installations with F. S. less than 1.00	7.0 per cent
Total installations with F. S. less than 1.25	17.5 per cent
Total installations with F. S. less than 1.33	30.0 per cent
Total installations with F. S. less than 1.50	39.0 per cent
Total installations with F. S. less than 1.75	66.0 per cent
Total installations with F. S. less than 2.00	78.5 per cent
Total installations with F. S. more than 2.00	19.5 per cent

3. Guy wire specifications.

4. Insulators in guys. Shorting of guy insulators to make the ground feature effective until such time as the insulator is to be used as an insulating unit.

Resolutions

The subcommittee on guying presents the following resolution:

1. That some member company make formal application to the Railroad Commission of the State of California for revision of General Order No. 64A permitting the use of a safety factor of 1.5 instead of 2 on all guys in grades of construction (A), (B) and (C).

2. That the report of the subcommittee on guying be accepted and presented, together with any additional data which may be collected in the meantime, to the California State Railroad Commission with the above application.

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*Method of Inspecting Poles in Service**

This report is a brief but fairly complete inspection program for the inspection of poles in service. The method of inspection as outlined in this report is, in general, the one used by The American Telephone and Telegraph Company as covered by their "Specifications 4,400." The tables are the ones used by the Pacific Gas and Electric Company in one of its divisions and have proved entirely satisfactory.

Method of Inspection

ASSUMING that each company has adequate pole records prior to the inspection, sheets should be prepared for the inspector, showing the location of the poles to be tested. They should include data on length, condition as to painting, stepping, and treating, date set, etc. Space should be left on the sheet for the inspector to fill in his findings regarding the condition of poles, to include circumference at ground line, circumference of sound wood, extent of termite infestation, number of pockets, amount of hollow heart, etc.

If a large urban area is to be tested, we would recommend that it be divided into convenient small sections. Inspection in each section should be completed before another section is started. This simplifies the preparation of reports, as well as the handling of such reconstruction as is found to be necessary.

Untreated poles should be tested at least once every four years. Perforated treated poles may be tested every eight years. Unless otherwise specified, all poles in a lead should be tested consecutively, omitting those which have not attained sufficient age.

The earth should be removed from around the butt of the pole for a sufficient distance below the ground line, usually from 12 in. to 18 in., in order that the circumference of the pole may be measured at the point of maximum decay. All rot should be removed until sound wood is exposed, care being taken to avoid any removal of sound wood. A 3-in. slick is very satisfactory for this operation. Some companies use a bar in testing poles. We do not believe one should be used in inspection, for the reason that it is apt to hasten decay by splitting the pole, by causing pockets in both treated and untreated poles, and particularly by leaving an entrance for termites in treated ones. Measurement should be made of the circumference at the point of maximum decay, with allowance for pockets and hollow hearts. If the circumference is found to be less than the minimum allowable circumference, the pole is in a dangerous condition and should be reported for attention.

Each pole should be sounded in numerous places, both above and below the ground line, by means of a hand axe to determine whether or not it is hollow. If the pole is hollow, the thinnest part of the shell may be determined by careful soundings, usually at about 6 in. below the ground line. Thickness of the shell may be determined by test borings, by noting at what depth the bit breaks through the shell and by observing the character of chips brought

* Report prepared by R. E. Hill for pole inspection subcommittee, line conductors subcommittee, overhead systems committee, Engineering Section. Ralph E. Hill, chairman. E. R. Banks, R. C. Barton, C. A. Bennett, A. M. Jeppesen, J. E. McDonald, H. Michener, C. P. Taylor, C. L. Yager.

out by the bit. A ⅝-in. bell-hanger bit, 18 in. in length, used with an 18-in. or 20-in. extension is very satisfactory for such borings. A prod made from a strand of guy wire, bent on one end to form a hook and calibrated in inches, may be used in measuring the shell, by inserting it into the hole bored in the pole, thus enabling the inspector to strike an average from the varying thicknesses.

Holes which have been bored in poles not requiring replacement should be carefully plugged with treated dowels. A ⅝-in. hole should be plugged with a ½-in. dowel. Maple dowels cut to 3-in. lengths and left submerged in creosote for 48 hr. will usually become fully impregnated. This type of dowel has proved satisfactory.

At times exposed pockets extending to various depths in the pole are found at or below the ground level where decay is generally the greatest. These pockets may be of such shapes and dimensions as to diminish seriously the strength of the pole. The width of a pocket is determined by taking the average width horizontally at the point of maximum decay. The depth should be measured from a straight edge placed across the pocket, the average depth being used.

Careful observation should be made for the ring rot, namely, the rot occurring between the annual rings in the heart of the pole, as well as for termite infestation and its resultant damage. Bulletin No. 318, published by the University of California, contains much useful data regarding the various types of termites and their habits.

When inspection is completed, the earth should be replaced around the pole and well mounded. When the replaced earth is insufficient to form a mound which will afford drainage away from the pole, additional earth should be added.

When poles are entirely surrounded by pavement which cannot be readily removed, test borings should be made at the ground level at an angle which will intersect the decay at the lowest possible point below the ground line, the resultant holes being plugged afterward with treated dowels.

A thorough inspection should be made of the condition of the pole above the ground line as to damage from woodpecker holes, splits, checks, and other defects which may affect the strength of the pole.

Tables showing the minimum allowable circumference for poles of various lengths, as well as for reduction in circumference for hollow hearts and exposed pockets, follow:

TABLE I

Length of Pole, ft.	Minimum Allowable Circum. in In. at Point of Maximum Decay	
	Heavy Duty	Light Duty
30	24	20
35	26	22
40	30	25
45	33	27
50	34	28
55	36	30
60	38	31
65	39	32
70	40	33
75	41	34
80	43	35

Note.—Any one of the following qualifications shall be considered sufficient to necessitate a pole being classed as a heavy duty pole:
Joint pole
Angle pole
Pole supporting transformers
Pole supporting crossings over streets, highways, primary lines, and railroads.
Pole subjected to heavy snow loading or wind.

TABLE II

EXPOSED POCKETS.

Depth of Pocket in In.	Width of Pocket in In.						
	2	3	4	5	6	7	8
	Decrease in circumference of equivalent pole in inches.						
1	1	2	2	3	3	4	5
2	2	3	4	5	6	7	8
3	2	4	5	6	8	9	11
4	3	4	5	7	9	10	13
5	3	4	6	7	9	11	..

Inspection should also be made for maintenance conditions, such as broken strain-bobs, loose clamps, etc., in guys; for rusty anchor rods; for broken conductor strands, loose tie wires, broken or cracked insulators, broken, rotted, or burned pins on poles.

From the experience of the Joint Pole Association and that of other companies in the northern part of California, two men have proved a satisfactory crew. Some of the companies, however, particularly in the southern part of the state, employ three men for the same work.

After a specified area has been tested, a detailed report should be made up, showing all of the essential data covered by the inspector's sheets. These should be prepared at least in duplicate, one copy for a permanent office record and the other for use of field men or engineers in planning reconstruction programs. Comparison can be made as to the relative condition of poles from the first and subsequent reports. If, for example, a pole were tested in 1927 and was found to have sufficient sound wood to allow it to remain in service, and the same pole were tested in 1931, the average decay could be easily ascertained. For the benefit of engineers in preparing reconstruction programs, the report should give the difference in inches of circumference between the remaining circumference of sound wood and the minimum allowable circumference at the present loading.

Testing Poles Before Climbing

Before climbing a pole, each employee should assure himself that it is strong enough to sustain his weight safely. If in doubt as to its soundness, it should be carefully sounded and tested with a pike or prod. When poles are found to be unsafe, they should be thoroughly braced by pike poles, or by guying or lashing to other poles. If the weight to be handled on the pole is large, or if the job is to be of long duration, the pole should be guyed or thoroughly braced by another pole, rather than by a pike pole, as the pike is apt to loosen under the swaying of the pole. This phase of the work is generally covered very thoroughly by safety rules adopted by the various companies.

Conclusion

It is not intended that the foregoing shall supersede any specifications now in use by any of the member companies, but it is intended to serve as a guide for any company desiring to adopt a definite inspection procedure. The method of inspection as described is being used by both The Pacific Telephone and Telegraph Company and the Pacific Gas and Electric Company in one of its divisions, with the exception that The Pacific Telephone and Telegraph Company uses the tables given in its "Specifications 4400" instead of the table given in this report.

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*Protective Devices**

Standardization of fuse links has progressed slowly but steadily. Their physical size and shape had been definitely fixed to make them interchangeable in all makes of expulsion-type cutouts, and now much interest is being manifested in the uniform rating of fuse links. Much confusion has crept into the problem, however, and in cooperative efforts thus far two distinct groups have developed, with the arguments advanced by each having sufficient merit to prohibit omission in the final prepa-

* Report of subcommittee on protective devices, overhead systems committee, Engineering Section. H. J. Schomberg, chairman. M. W. Clark, O. R. Evans, Homer Keesling, C. S. King, H. H. Minor, C. A. Bennett, G. M. Richardson, Ray Sheppard, C. C. Potts, C. F. Dalziel, J. C. Porter, A. J. Pahl, F. J. Gleiss, G. M. Babcock, B. C. Holst, H. F. Hartzell.

ration of specifications, which will probably constitute a compromise between operating requirements and the best product that can be economically supplied.

Automatic oil circuit breakers of the pole-mounting type, in ratings of 15,000 volts and below, are not extensively manufactured or used. There is one very good line of such switches available, but those operating companies who have standardized upon this type of protective equipment are in the minority.

New developments classified as protective devices, are comparatively few in number, but those which have appeared all incorporate schemes for insuring greater continuity of service and safety of operation.

THE work of the protective devices subcommittee this year has been a continuation of that started last year, supplemented by the collection of some rather limited data on the use of pole-top oil circuit breakers for transformer protection.

Replies to a questionnaire sent out to the member operating companies at the beginning of the year indicated insufficient interest in the subject of pole-top oil circuit breakers for transformer protection to justify much time being spent on this phase of our work. Therefore, most of our efforts have been devoted to an attempt to standardize further the method of rating the renewable, high-voltage a.c., box and open-type fuse cutouts, employing the expulsion principle for distribution service of 15,000 volts and below.

During the past few years, considerable work has been done toward standardization of the physical size and shape of fuse links, until now we have what is known as the "universal" fuse link, which is interchangeable in all the modern makes of expulsion-type cutouts.

Until within the past year, every manufacturer of fuse cutouts has worked out his own method of rating, depending generally upon the kind of material, or combination of materials, from which he was making the fusible elements. This situation has naturally led to dissatisfaction and confusion, due to the unfounded but general belief on the part of those in the electrical industry who install and replace the fuse links, that a link will carry continuously the amperes corresponding to the number stamped on the link. The operators have assumed without question that a fuse link would carry its rated amperes continuously if occasion required it, just like switches or any other piece of electrical equipment. Their assumption was logical, but they found by sad experience that it did not work out in practice. Such cases of "fuse outages," while comparatively few in number, usually occur at the most inopportune time or under the most adverse conditions, so that in either event the serviceman who restores service does so as quickly as possible, usually re-fusing with links of higher rating so as absolutely to insure future continuity of service, which is paramount.

Let us assume that, following the restoration of service, the blown fuse links were checked to determine whether they were the proper size according to the fusing standard established for the protection of such service. Upon finding them to have been correct in size, what explanation can be given for the interruption? There are but two possible reasons, neither of which is correct, and so that matter is taken for granted as being just another one of those things which happen. In order to avoid recurrence of an interruption to this important service, the fusing ratio has been increased to the point where the fuse will not operate to isolate further trouble, with the ultimate result that the reliability of service of the main feeder is impaired. Perhaps a bit of history might well be injected here to show how such confusion has crept into the problem of fuse rating.

About two years ago, a small subcommittee of the N.E.L.A. overhead systems committee tentatively adopted the following rating:

> Fuses shall carry the rated capacity indefinitely without causing visible deterioration of the cartridge and shall blow at 125 per cent of rated capacity, plus or minus 10 per cent in five minutes in any fuse-box.

The rating just quoted calls for 100 per cent carrying capacity of the fuse indefinitely. One of the manufacturers, being appointed a committee of one by the N.E.M.A. to interview the members of this N.E.L.A. subcommittee, apparently gained the impression that "speed of operation" of the fuse links was all that the N.E.L.A. members desired and overlooked the matter of rating as being of great importance. This particular manufacturer was making zinc links and could not produce a link which would carry the 100 per cent rated current indefinitely without deterioration of the fuse tube, and at the same time meet the above-mentioned blowing-time requirements.

The rating used by another manufacturer was entirely different, it meaning that the fuse would blow at the rated current within a reasonable time and that the link would carry only 50 per cent of its rating continuously.

These fundamental differences in rating have resulted in the necessity for use of fuse links of different ampere ratings to protect a given size of transformer, depending upon the make of fuse link used.

At a meeting of six manufacturers at Hot Springs in 1930, the rating tentatively adopted by the above-mentioned N.E.L.A. subcommittee was slightly modified to read as follows:

> Cutouts shall be rated in RMS amperes and their fuse links shall carry their rated current for one hour without causing visible deterioration of the fuse link or adjacent parts. Fuse links shall not be operated continuously at over 65 per cent of their rated current. They shall blow at 125 per cent, plus or minus 10 per cent of their rated current within five minutes, with an ambient temperature of 20 to 30 deg. C., except fuses rated below 5 amp., which shall blow at less than 200 per cent rated current within five minutes.
>
> The temperature rise of any part of the fuse unit except the fuse element above an ambient of 40 deg. C., when tested at 65 per cent of rated current, shall not exceed 50 deg. C. on all other fuse parts in contact with or adjacent to Class A and B insulating material.

When it came to voting by ballot letter, the blowing percentage was raised from 125 to 150 by all but one of the manufacturers, who claimed he could meet the 125 per cent requirement.

Here is where the trouble began, because the manufacturer who opposed the increase in blowing percentage immediately discussed the matter of N.E.L.A. rating with some of the N.E.L.A. members, who apparently agreed with the manufacturer, and he in turn conveyed the impression back to the N.E.M.A. that the N.E.L.A. members were favorable to the so-called 65 per cent method of rating. The N.E.M.A. promptly adopted this standard in March, 1931, and have printed it as rule No. SG9-11 of their rating standards, as applying to inclosed renewable high-voltage a.c. fuse cutouts for distribution service of 15,000 volts and below.

All this misunderstanding could have been avoided if the continuous carrying capacity had remained at 100 per cent and the blowing percentage had been raised from 125 per cent to 225 per cent.

When the question of whether or not a fuse should be so rated as to carry its rated current indefinitely was submitted to the N.E.L.A. overhead systems committee for discussion at its St. Louis meeting in February, 1931, a vote revealed the majority favoring the 100 per cent method of rating. During the St. Louis meeting a conference of operating men and manufacturers was held for the purpose of preparing tentative specifications for fuse cutouts and fuse links, at which meeting the operating men unanimously agreed that:

> Fuses shall carry 100 per cent of their rated current indefinitely and that the temperature shall not exceed 50 deg. C. above an ambient temperature of 20 to 25 deg. C.

With reference to blowing time characteristics, it was also suggested that:

Fuses shall blow within four seconds at 450 per cent of their rating and in less than one second at 750 per cent of their rated current.

It was understood that these two points on the time-current curve were tentative and subject to change upon receipt of the time-current curves for fuses based upon the 100 per cent rating, which the manufacturers agreed to supply. Due to lack of definite information on various points, it was decided to submit a questionnaire to the membership of the N.E.L.A. overhead systems committee, the purpose of this questionnaire being to obtain an expression of the characteristics desired and to coordinate the views of operating men so as to outline the requirements of this equipment to the manufacturer.

The questionnaire contained an outline of the proposed specifications for fuses and comments were invited, with specific information being requested on two points: namely, (1) to supply time-current curves for breaker operation on distribution circuits, and (2) to indicate a preference for definition of rating. Your chairman does not have the present status of this questionnaire, but on Oct. 5, 1931, replies to 39 of the 66 sent out had been received, 22 of which favored the 100 per cent method of rating, 4 favored the 65 per cent method of rating; in 12 the subject was disregarded and one expressed no preference.

From the above history of fuse cutout rating, it is evident that some consideration has been given to the question by both the operating companies and the manufacturers, but it is only within the current year that there has been any indication of coordination between the two, with the operating companies endeavoring to agree among themselves upon the requirements for such equipment and the manufacturers making special effort to produce fuse links having greater speed of operation with lower operating temperature.

Following the completion of the current year's work by the N.E.L.A. and various sectional committees who have been studying the problem, it is anticipated and hoped that a very definite set of specifications may be prepared, constituting a compromise between the requirements of operating companies and the best product which manufacturers are able to supply economically.

Fuse-Link Rating for Expulsion-Type Cutouts

With the interrupting duty and normal load cycle determined, the selection of proper fuse links depends on the basis of rating and the time-current characteristics. Obviously, for best application, the basis for fuse-link rating should be known and, if possible, be the same for all makes of fuses used for the same service. Efforts toward this goal have progressed sufficently far to divide into two distinct groups, one group favoring the 65 per cent basis of rating and the other favoring the 100 per cent basis.

To avoid misunderstanding, a definition of the 100 per cent basis of rating is as follows:

The 100 per cent rating shall be that maximum value of current in RMS amperes which the fuse element will carry indefinitely without any part of the fuse cartridge or holder exceeding a predetermined rise of temperature above a fixed ambient temperature, the fuse blowing at a given percentage above the maximum value within a stated time.

Copies of the above-mentioned N.E.L.A. questionnaire were likewise distributed to each member of our P. C. E. A. protective devices subcommittee, with a specific request for replies on preference of fuse rating. As of March 1, the status of this P.C.E.A. questionnaire is as follows:

Copies of questionnaire sent out	17
Replies received	15
100 per cent method of rating preferred by	12
65 per cent method of rating preferred by	2
No preference	1
No replies received	2

Of the twelve replies received favoring the 100 per cent method of rating, eleven were from operating companies and one from a manufacturer. The two replies favoring the 65 per cent rating were from manufacturers and one manufacturer expressed no preference.

The proponents of the 100 per cent basis of rating have as their argument that it is consistent with the rating of all other electrical equipment and would have a definite meaning, whereas the present, or 65 per cent method of rating is purely nominal, without giving the continuous carrying capacity or the blowing-current value.

Those defending the present or 65 per cent method of rating, advance the arguments that:

1. It is the common practice of operating companies to protect the transformer with fuses having an average minimum ratio of fuse rating to full load current of two, which means that the transformer would have to carry at least a 30 per cent overload continuously before the continuous carrying capacity of the fuse link and container would be reached; therefore, the present rating is satisfactory.

2. De-rating all of the present fuse links, calling the present 65 per cent point the 100 per cent rating of the fuse link, would involve a minimum reduction in the present fusing practice of about 25 per cent in order to maintain the same degree of protection. It would also involve a revision of the blowing percentage, increasing it from 150 per cent to 230 per cent for sizes above 5 amp., and from a maximum of 200 per cent to 310 per cent for sizes below 5 amp.

Time-Current Characteristics of Expulsion-Type Fuse Links

It has only been within the past year that the manufacturers have stressed the time-current characteristics of their fuses, and it is probable that with these curves now available the present fusing practice of the operating companies will be materially modified.

It should be recognized that any tests attempting to time the explosion or burning of metals in an inclosed chamber are naturally subject to considerable variations. The time required for the fuse link to operate is divided into two parts; first, the time required to heat the fuse link to the fusing point of the material from which it is made and, second, the time required to interrupt the arc after the fuse link melts. This fusing time depends upon the temperature of the fuse link immediately preceding the application of the fault current and the magnitude of the fault current. The speed at which the arc is extinguished in an expulsion-type cutout depends upon the expulsive pressure resulting from the heat generated by the arc and vaporization of the fuse-link metal. Since the interrupting capacity rating of the cutout tends to regulate the bore of the fuse tube, it is evident that large-bore tubes are required for interrupting currents of short-circuit proportions to avoid pressures in excess of the fiber stress of the tube, and small-bore tubes are required for interruption currents of low value. The length of the fuse tube also affects the pressure and, for satisfactory interruption of currents of reasonably high and low value, a compromise in the bore for good over-all design has resulted.

Proper selection of fuse links from their time-current curves should involve consideration of corresponding characteristics for the relays controlling the operation of oil circuit breakers protecting the feeder. To show what may be expected when relayed breakers are placed in series with fuses, such as would result in the protection of branches from the main feeder with fuses, relay time curves and fuse time curves have been plotted to the same scale, as shown by Fig. 1.

The fuse curves which lie entirely to the left and below the relay curves should result in selective operation, while those curves or portions thereof which lie to the right and above the relay curve will result in tripping the breaker before the fuse can operate to clear the circuit. In cases where the curves intersect, selective operation is questionable, depending upon the magnitude of the fault current, breaker opening, arcing time, etc.

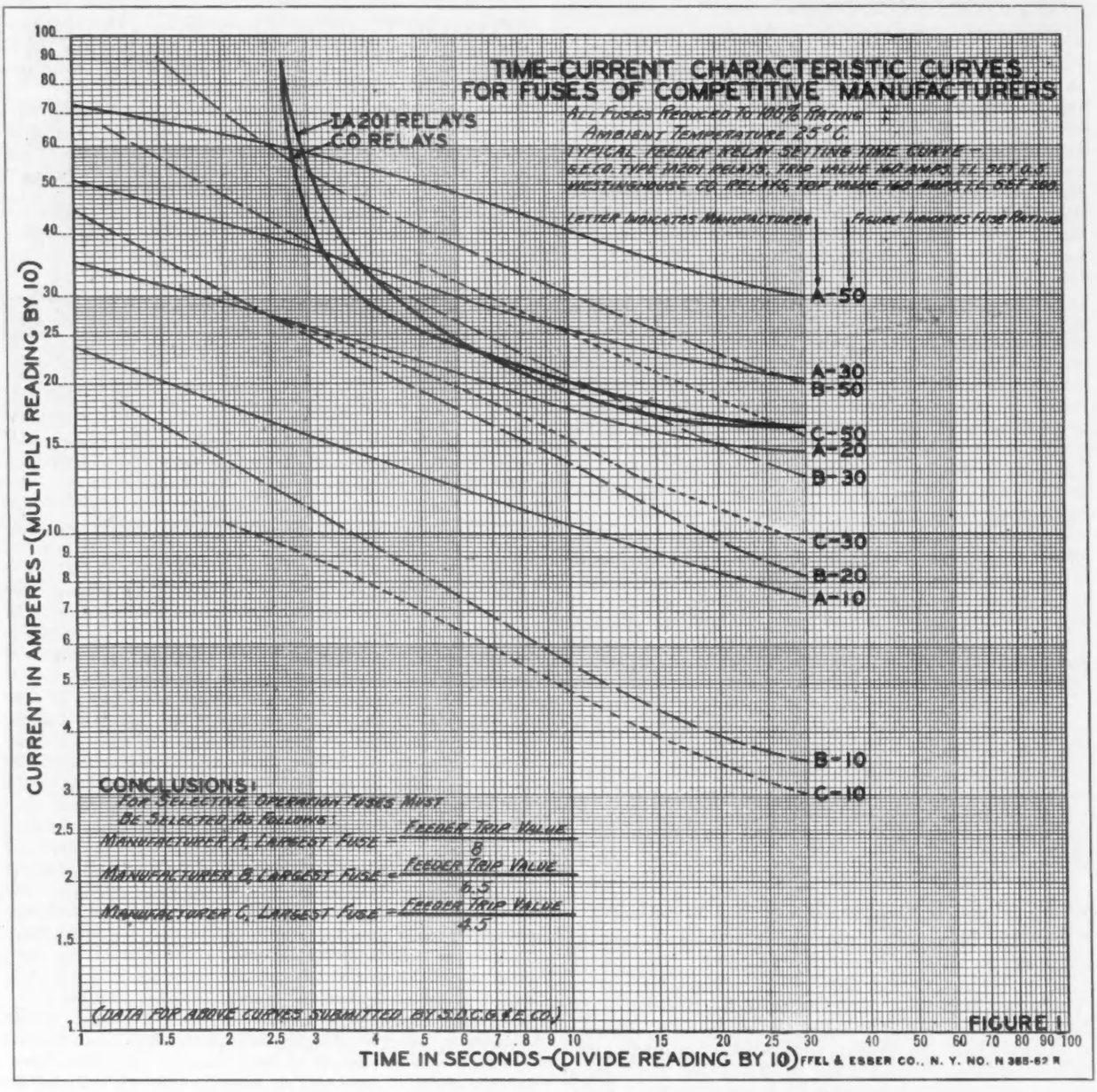
TIME-CURRENT CHARACTERISTIC CURVES
FOR FUSES OF COMPETITIVE MANUFACTURERS
ALL FUSES REDUCED TO 100% RATING
AMBIENT TEMPERATURE 25° C.
TYPICAL FEEDER RELAY SETTING TIME CURVE —
G.E.CO. TYPE IAC01 RELAYS, TRIP VALUE 140 AMPS. T.D. SET 0.5
WESTINGHOUSE CO. RELAYS, TRIP VALUE 140 AMPS. T.D. SET 5.0
LETTER INDICATES MANUFACTURER
FIGURE INDICATES FUSE RATING
IA 201 RELAYS
CO RELAYS
A-50
A-30
B-50
C-50
A-20
B-30
C-30
B-20
A-10
B-10
C-10
CURRENT IN AMPERES—(MULTIPLY READING BY 10)
TIME IN SECONDS—(DIVIDE READING BY 10)
CONCLUSIONS:
FOR SELECTIVE OPERATION FUSES MUST
BE SELECTED AS FOLLOWS:
MANUFACTURER A, LARGEST FUSE = FEEDER TRIP VALUE / 8
MANUFACTURER B, LARGEST FUSE = FEEDER TRIP VALUE / 6.5
MANUFACTURER C, LARGEST FUSE = FEEDER TRIP VALUE / 4.5
(DATA FOR ABOVE CURVES SUBMITTED BY S.P.C.G. & E. CO.)
FIGURE 1
FFEL & ESSER CO., N. Y. NO. N 365-62 R

Fig. 1—Time-current characteristic curves for fuses of competitive manufacturers

There has been a tendency to consider that no change can be made in the existing relay practice, but where serious consideration has been given to the matter it has been found possible to change the practice and to provide a greater ratio between the fuse and relay. A very important point which is often overlooked is that the minimum ratio between the normal feeder current and the relay setting is not compared with the corresponding ratio of the fuse link and its normal current, thereby resulting in unnecessary interruption of the entire feeder, due to a fault current of sufficient value to operate the breaker relays without blowing the fuses.

Poletop Oil Circuit Breakers for Transformer Protection

An inquiry and request for information sent out to fifteen manufacturers of oil circuit breakers has revealed that only four of these build switches suitable for mounting on a single pole in voltage ratings of 15,000 volts and below. Of these four, only two build switches which are suitable for use in the protection of transformers against overload or short-circuit currents.

One of these two manufacturers has developed the pole-mounting type of breaker as one of his specialties. These are applicable to a great many types of installation, being particularly well adapted to construction requirements within the state of California. These breakers employ the series overload-trip principle, having one series coil in each phase, and are equipped with dashpots which serve to provide sufficient time delay to prevent the breaker opening, due to momentary surges on the line. The distinctive features of this switch are that the tripping point can be readily changed from outside the tank while the switch is carrying current, and that it is designed for manual operation only. This line of breakers provides an inexpensive but thoroughly reliable outdoor oil circuit breaker for distribution line voltages, ranging from 2,200 to 15,000, and in current capacities from 125 to 400 amp.

The other manufacturer lists as one type of his group a switch which is suitable for wall or pole mounting for capacities up to 600 amp. at 7,500 volts, or 800 amp. at 4,500 volts. This switch is designed for attaching to flat surfaces, such as a wall or on the side of a crossarm, and cannot be suspended from a double crossarm without the use of special hangers. Due to the method of mounting this switch, its

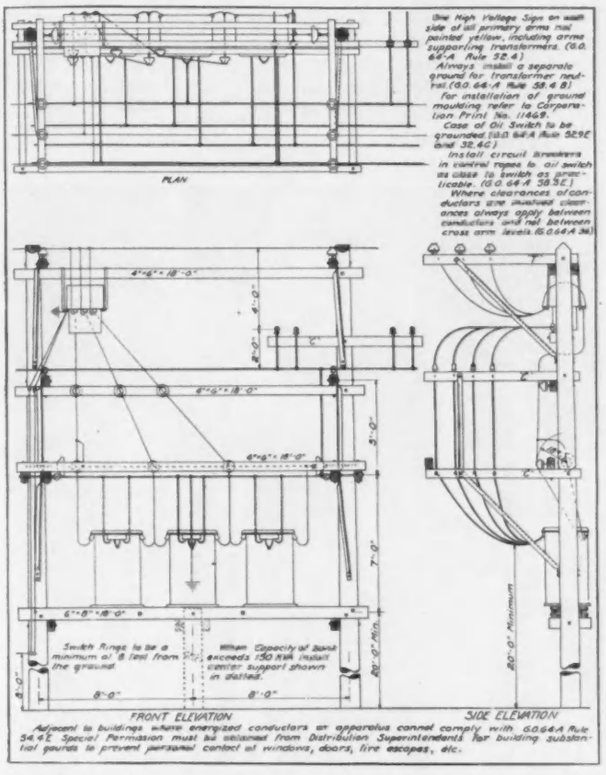

Fig. 2—Transformer structure with oil circuit breaker, 11-kv. alley construction, San Joaquinn Light & Power Corp.

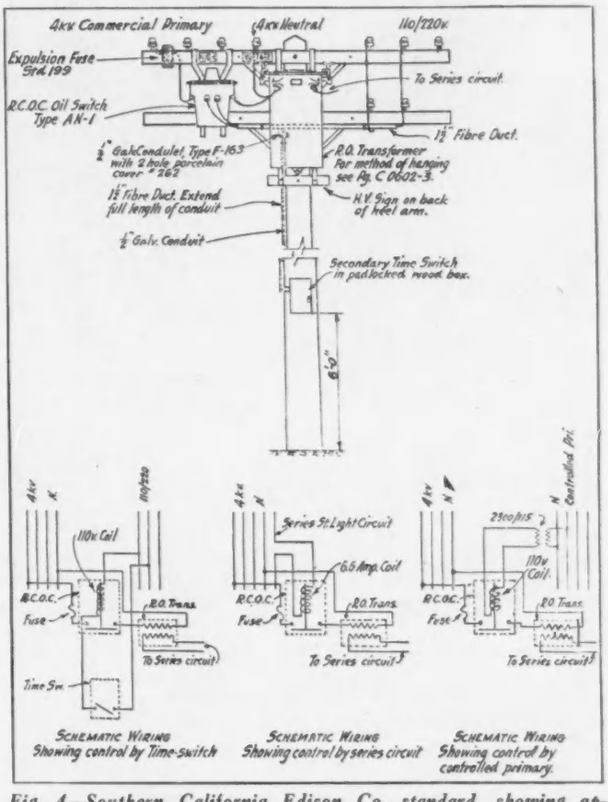

Fig. 4—Southern California Edison Co. standard, showing application of R.C.O.C. pole-top oil switch for street light control

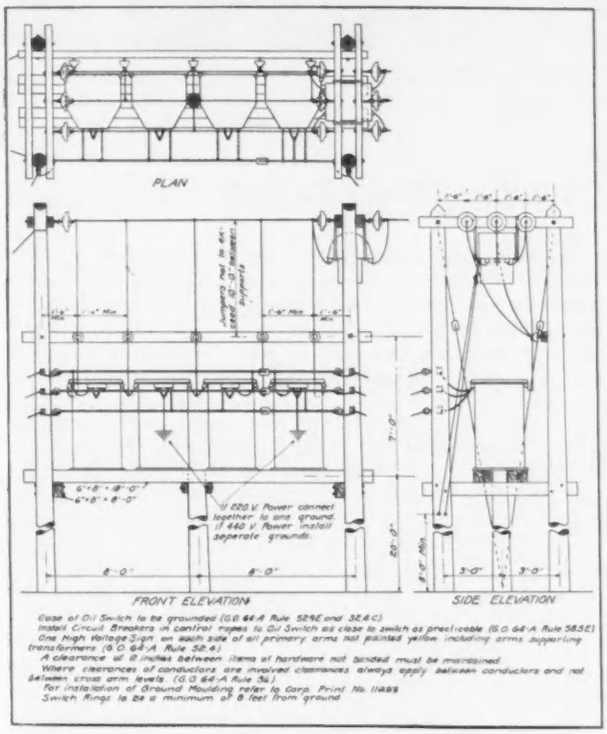

Fig. 3—Transformer structure with oil circuit breaker, 11-kv. power and lighting

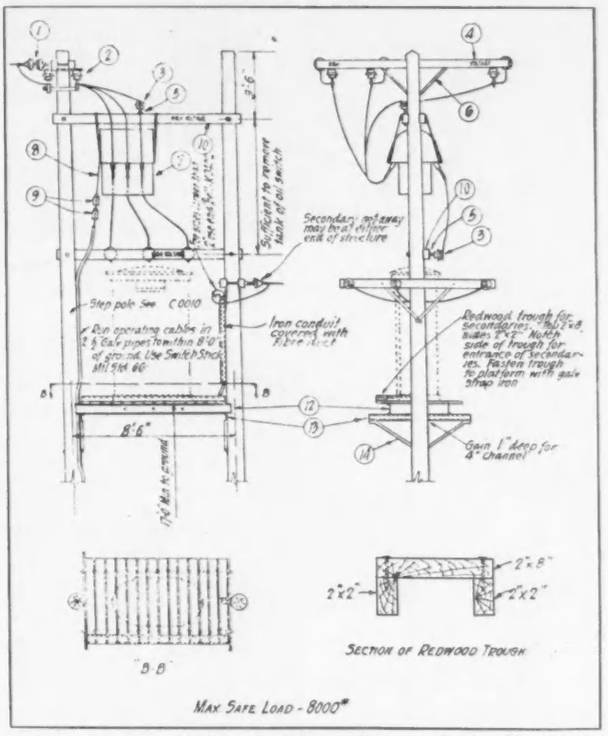

Fig. 5—Southern California Edison Co. standard, showing application of automatic oil switch for protection of 11-kv. or 16-kv. three-phase transformer installation of capacities in excess of 50 kva.

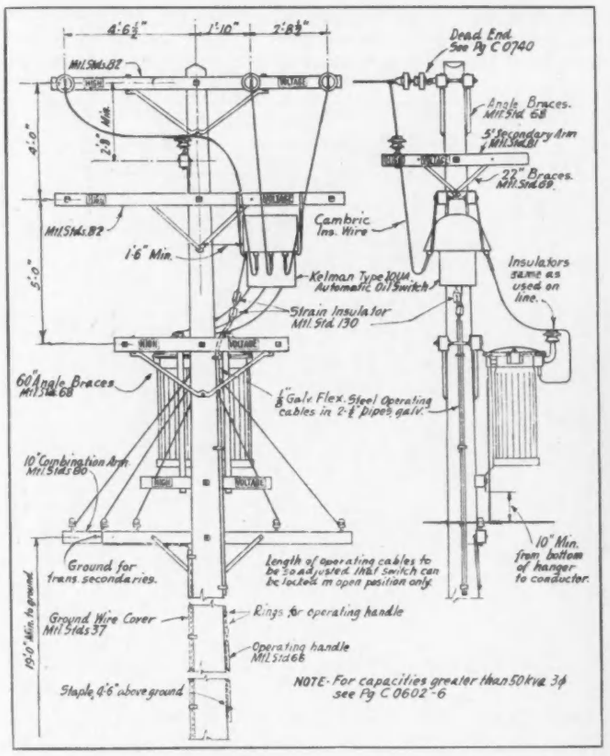

Fig. 6—Southern California Edison Co. standard, showing application of automatic oil switch for protection of 11-kv. three-phase transformer installation in capacities of 50 kva. and below

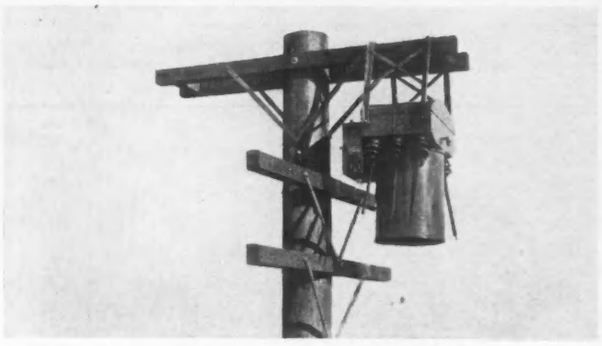

Fig. 8—Oil circuit breaker of the new heavy-duty type with hangers for suspending from double arm

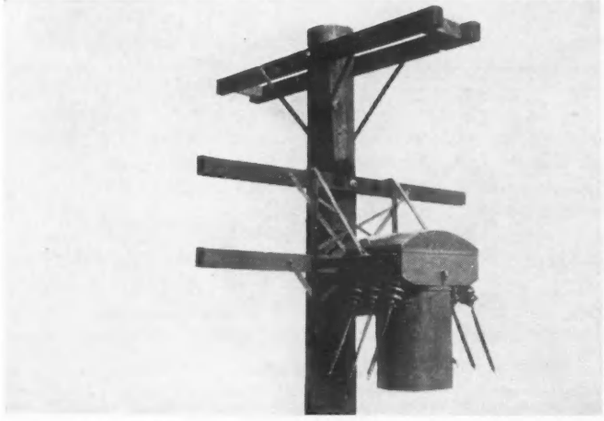

Fig. 9—Oil circuit breaker of the new heavy-duty type with bracket-type mounting

installation is more expensive and it is not as well adapted to installation requirements as its competitor for the application under discussion. Its distinctive features are its form of wedge and finger-type contacts, auxiliary arcing contacts and tip springs, and its isolation of poles by individual cells. These breakers, up to 400-amp. capacity, employ the series overload-trip principle having series coils in but two of the three phases, which make them undesirable for use on Y connected circuits, because one phase is not protected. For the current capacities above 400 amp., the series-transformer overload-trip principle is employed, being equipped with

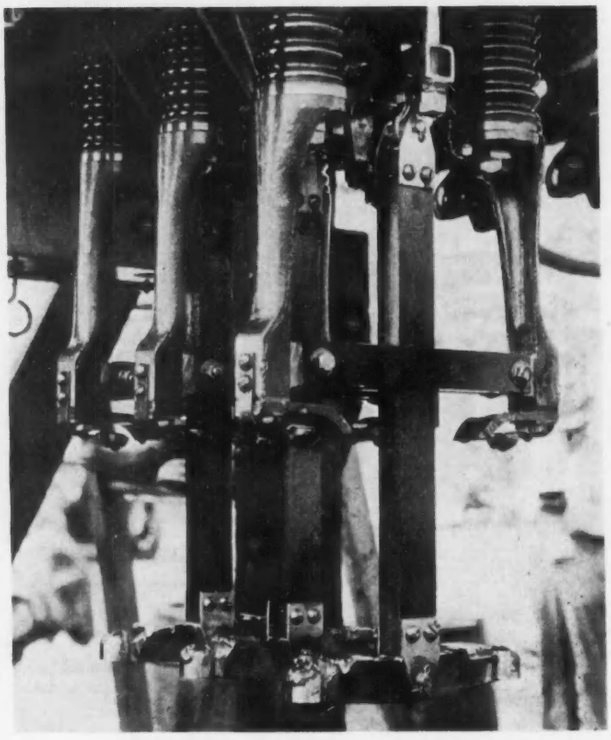

Fig. 10—Condition of contacts in oil circuit breaker of the new heavy-duty type after 6,000 operations at 1,930 R.M.S. amp., 17,000 volts, 57,200 kva.

bushing-type current transformers and, by connecting the two trip coils in "Z," full protection is provided on all three phases.

Replies to a questionnaire sent out at the beginning of the year to the operating company representatives on our committee reveal that but two of the six standardize upon the use of poletop oil circuit breakers for protection on the line side of transformer installations, where the supply voltage is 17 kv. or below. The other four companies report having such installations on their respective systems, but state that they are the result of special service requirements or that the original installation dates back to the time when automatic circuit breakers were comparable in price with available cut-outs that were then none too reliable in their operation. Of those companies having poletop breaker installations on their systems, all report their breakers set for protection against currents of short-circuit magnitude which may develop on the secondary side or arise from a breakdown within the transformer.

Figs. 2 and 3 are illustrative of standard installations as used by the San Joaquin Light & Power Corp., showing the application of poletop oil circuit breakers.

Figs. 4, 5 and 6 are illustrative of standard installations as used by the Southern California Edison Co. Ltd., showing applications of similar breakers.

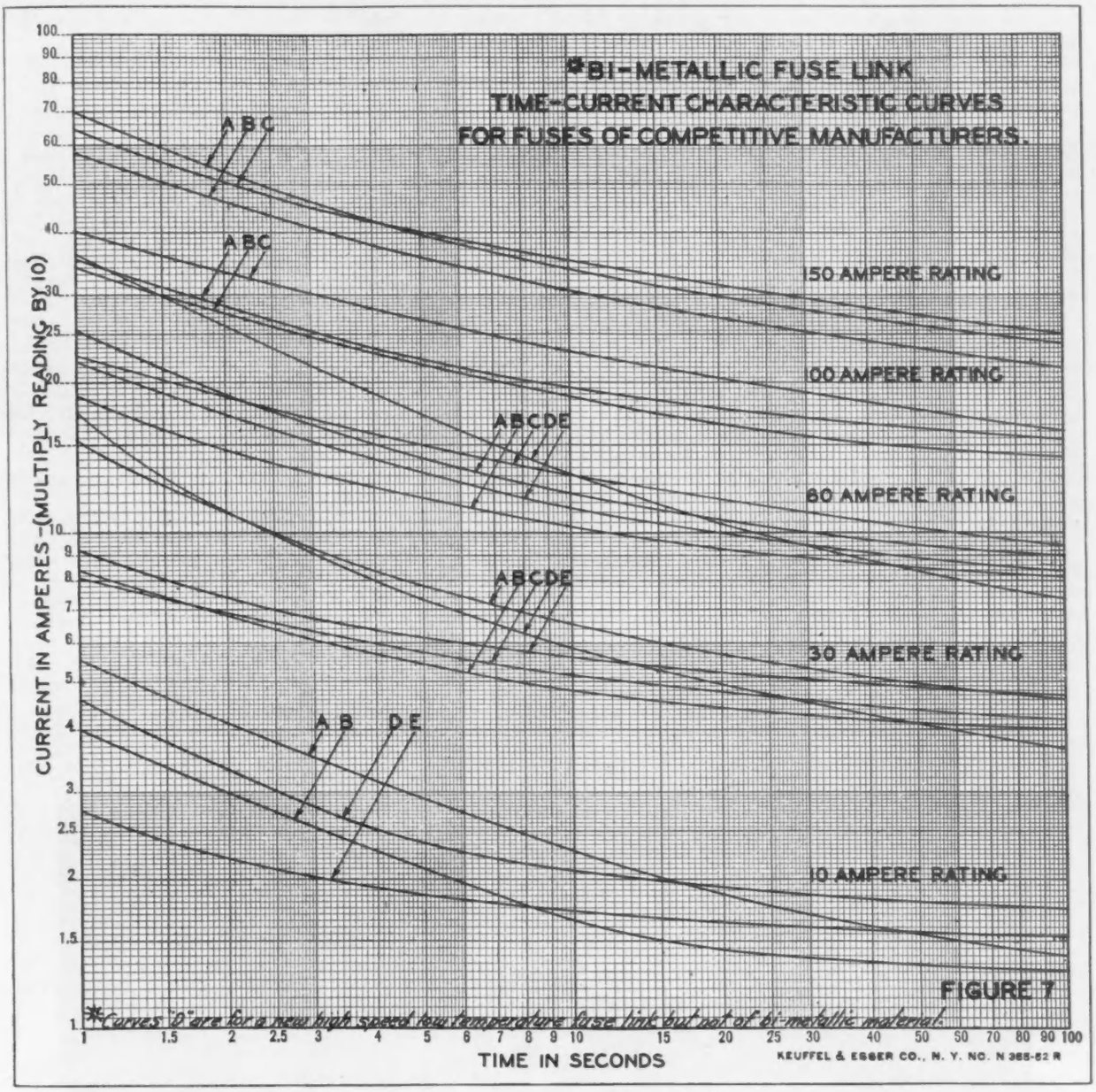
*BI-METALLIC FUSE LINK
TIME-CURRENT CHARACTERISTIC CURVES
FOR FUSES OF COMPETITIVE MANUFACTURERS.
CURRENT IN AMPERES - (MULTIPLY READING BY 10)
TIME IN SECONDS
A B C
A B C
A B C D E
A B C D E
A B D E
150 AMPERE RATING
100 AMPERE RATING
60 AMPERE RATING
30 AMPERE RATING
10 AMPERE RATING
*Curves "D" are for a new high speed low temperature fuse link but not of bi-metallic material.
KEUFFEL & ESSER CO., N. Y. NO. N 385-52 R

FIGURE 7

Fig 7—Bimetallic fuse link time-current characteristic curves for fuses of competitive manufacturers

New Developments

Fuse Links—

Within the past four months, three of the major manufacturers of fuse links have placed on the market what they call their new "bimetallic" links, having the outstanding features of high-speed operation with low operating temperature. It is understood that another manufacturer has completed his research work and is prepared to start production of a similar fuse link.

These new links, it is claimed, embody the desirable features of previous links, the fusible part being a reduced section of metal having a low melting point, perfectly bonded to a terminal cap at one end and leader at the other, of material having higher thermal and electrical conductivity and other characteristics insuring maximum interrupting capacity.

The unique construction of these fuse links results in localization of the heating in a small section of the fuse, thus reducing the I^2R losses to be dissipated and the excessive gas pressure created on rupturing under short-circuit conditions.

These links are extremely efficient in their speed of operation on low current values. Fig. 7 shows the time-current characteristics of these competitive bimetallic links for various ratings.

The curves marked (D) represent similar characteristics for the recent product of a manufacturer who is producing expulsion-type cutouts and links up to 60-amp. rating. These links are not bimetallic.

Poletop Oil Circuit Breakers—

A Pacific Coast manufacturer has recently placed on the market an oil circuit breaker which is particularly intended to fill the need for a new type of fairly heavy-duty pole-mounted breaker. This breaker is designed for currents of 200 and 400 amp., with an interrupting capacity of 50,000

kva., and is recommended for use on a.c. systems up to and including 17,000 volts. The breaker may be manually or electrically operated and is automatic, employing the series-transformer overload-trip principle, being equipped with bushing-type current transformers.

This switch was placed in service on the Southern California Edison Company system approximately a year ago and extensive tests have indicated that it will meet the requirements of engineers and operating men.

Figs. 8 and 9 show the methods of mounting the switch and Fig. 10 shows the condition of the contacts after the switch had been subjected to a series of very severe tests.

Adjustable Signal Relay—

This relay has been recently placed on the market and serves the need for an inexpensive reliable signaling device for assistance in locating trouble on distribution circuits and also serves as an indicator that some abnormal condition has occurred on the lines.

The relay has a calibrating feature which permits its adjustment so as to operate satisfactorily on current values of 200, 300 and 400 amp., and also to function at the same overload as the primary feeder oil switch. The minimum current required to hold up the armature is 80 amp.

Tests have shown these relays to be very sensitive and positive in their action and that the current required to operate them may be reduced by looping the conductors through the relay two or more times.

Protective Cutout Relays—

A new type of cutout relay was advertised in *Electrical World* for Dec. 19, 1931. The relay is suitable for operation in connection with an R-C-O-C oil switch and its function is automatically to cut off the primary supply to a constant-current regulating transformer in the event of an open circuit occurring in the series secondary of the regulator, thus safeguarding pedestrians against coming in contact with overhead conductors of series lighting circuits which have fallen to the ground.

Conclusions

The replies to the questionnaire to which reference is made above show without doubt that the operating companies are greatly in favor of the 100 per cent method of rating fuse links instead of the present 65 per cent method. The manufacturers answering the questionnaire are divided in their opinions, two favoring 65 per cent, one 100 per cent and the fourth giving no preference.

At its meeting held in Fresno on March 9, 1932, the overhead systems committee of the P.C.E.A. expressed itself unanimously as favoring the 100 per cent method of rating.

PRIME MOVERS COMMITTEE REPORTS[1]

THE public utilities of California produced 8,795,700,000 kw.-hr. of electrical energy during the year 1931. Although this is 1.74 per cent less than the output of the previous year, it compares favorably with the 4.4 per cent national decrease for this industry. Due to deficient rainfall, the state's output by water power decreased 1,682,710,000 kw.-hr., or nearly 25 per cent, while the output by steam generation increased from 2,144,164,000 kw.-hr. in 1930, to 3,674,248,000 kw.-hr. in 1931, an increase of 71 per cent.

All the major companies in this territory were well equipped with modern steam plants of ample capacity, such that the additional steam load was carried without curtailment of energy to consumers.

Our steam plants used during the year 1,188,287 bbl. of fuel oil, and 45,033,312,000 cu.ft. of gas, the increased load being carried almost entirely by the development of new sources of natural gas fuel, the use of which increased by about 75 per cent this year.

The prime movers committee of the Pacific Coast Electrical Assn., through its meetings and published reports, represents the activities of this geographic division in the steam generation of electric energy. It affords the principle medium for the exchange of data and ideas between the operating and designing departments of this important part of the local industry. The completion of the high pressure installation at Station "A" of the Pacific Gas and Electric Co. and the operating records from other large plants in this division, provide information of considerable interest to local engineers and also contribute liberally to the reports of the National Electric Light Assn.

The larger utilization of steam power was evidenced by increased attendance at the regional meetings of the prime movers committee and the submission of an unusual amount of material for discussion at these meetings.

The subcommittee on review, first organized in 1929, has done much constructive work along the lines of improved organization of subcommittee work in general.

Recommendations made by this subcommittee were included among the final reports published by the prime movers committee in 1930 and 1931. (See *Electrical West*, May 15, 1930, pp. 438-9 and May 15, 1931, pp. 446-7.) For the most part these recommendations have been carried out with beneficial results. It is the opinion of this subcommittee that no further recommendations should be made at this time, but that an effort should be made to work out in practice to still greater advantage those recommendations already submitted.

In accordance with the permanent classification of subcommittees adopted in 1930, the work of the prime movers committee is done by twelve subcommittees, nine of which were active during the past year. Although each of these subcommittees presented valuable reports, a stringent economy program made it appear desirable to publish only those of most general interest. Accordingly, although the reports on instruments, turbo-generators, and boilers, will be mimeographed for limited circulation, the published reports will include only the following:

Condensers and Auxiliaries—
Condenser cleaning versus chlorination.
Composition of condenser tubes.
Condenser performance records.

Station Piping—
Design of 1,400-lb. piping and fittings for Station "A" of the Pacific Gas and Electric Co.

Heat Balance, Design and Plant Betterment—
Over-all economy characteristics of 1,400-lb. units at Station "A" of the Pacific Gas and Electric Co.

Plant Management—
Study of labor distribution in a Pacific Coast plant.
Comparison of salaries in three different plants.
Health records of employees.

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[1] L. J. Kraps, Southern California Edison Company Ltd., chairman. V. F. Estcourt, Pacific Gas and Electric Company, vice-chairman. General Electric Company: R. F. Monges, E. E. Valk. Hawaiian Electric Company: L. A. Hicks, R. J. Thomas. Leeds & Northrup Company: N. Cohn. Los Angeles Gas and Electric Corporation: H. E. Thompson, F. R. Knight, E. G. McDonald, W. C. Poe, C. H. Zeise. C. C. Moore & Company, Engineers: D. P. Vail. Pacific Gas and Electric Company: M. R. Born, L. D. Burlingame, P. E. Chapman, C. H. Delany, A. K. Ingraham, H. S. Markey, H. N. Mosher, M. E. Mulkey, W. N. Munro, P. A. Person, R. C. Powell, J. M. Renfrew, C. E. Steinbeck, F. B. Stillwagon, L. Williams, J. T. Youd. San Diego Consolidated Gas & Electric Company: R. V. Major, H. A. Nobel, E. D. Sherwin, C. W. Wiggins. San Joaquin Light & Power Corporation: A. Y. Meudell, E. A. Quinn, H. T. Shirley. Southern California Edison Company Ltd.: H. C. Bennett, W. P. Day, G. K. Gordon, T. M. Hotchkiss, F. G. Philo, A. Sattler, W. H. Short, W. E. Thompson, R. A. Wallingford, R. Wilcox, D. P. Woolley. The Southern Sierras Power Company: V. E. Johnson. Westinghouse Electric & Manufacturing Company: C. H. Brunner.

*Condensers and Auxiliaries**

Chlorination of circulating water is referred to and tests on aluminum bronze condenser tubes are also mentioned. A detailed report by D. P. Woolley of the Southern California Edison Company Ltd., on the subject of condenser performance, is also included. In this report the graphic condenser records for two 100,000-kv. turbines are shown. The methods of obtaining the results are also given. Various factors which have been found to affect condenser readings are mentioned. This is followed by a short discussion of condenser calculations.

Condenser Cleaning Versus Chlorination

AS STEAM plant efficiency may be affected very greatly by good or poor condenser operation, this subject is an important one. Failure of condenser tubes and methods of cleaning them are subjects which have been given a great deal of study by the best engineering talent for many years. Satisfactory cleaning methods have been developed, but the use of chlorine in circulating water, which is being given a trial in the Long Beach plant and the Station "A" plant, may further simplify the cleaning problem.

Composition of Condenser Tubes

During the past few years Admiralty brass has been commonly accepted as the most satisfactory metal for condenser tubes but a great deal of trouble with pitting and corrosion of tubes has continued where sea water is used for cooling water. During the past year some trial installations of tubes other than Admiralty metal have been made with prospects to date of considerable improvement in length of service without failure.

In the Long Beach plant of the Southern California Edison Co. Ltd. three lots of 100 tubes each, of three brands of tubes, were installed for trial. One lot was of nickel alloy, another was of tubes made by the cupping process, and the other the standard Admiralty tube.

In the Seal Beach plant of the Los Angeles Gas and Electric Corp. and Station "B" of the San Diego Consolidated Gas & Electric Co., trial installations of aluminum-bronze tubes made in England are in service. Some interesting information should be available for future reports, after these trial installations have been in service a longer time.

The Value of Condenser Performance Data—

The condensing equipment on each of the two 100,000-kw. turbines of the Long Beach steam station comprises four

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* Report of subcommittee on condensers and auxiliaries, prime movers committee, Engineering Section. C. W. Wiggins, chairman. F. R. Knight, M. E. Mulkey, A. Y. Meudell, Leonard Williams, D. Park Woolley.

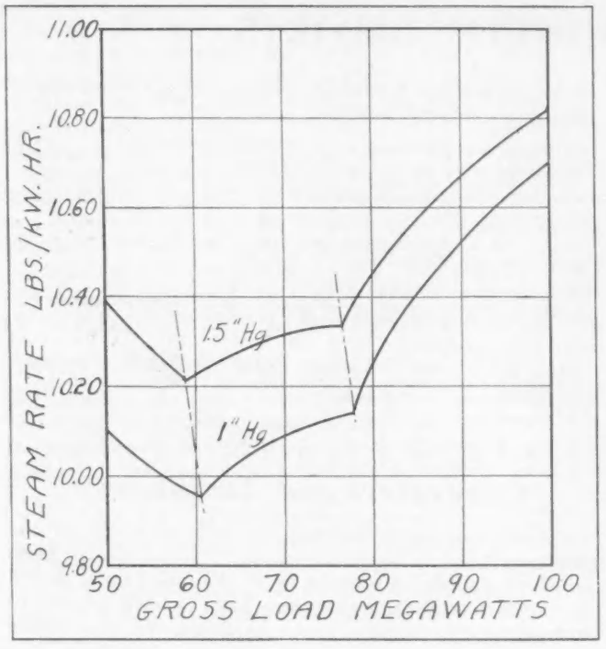


Fig. 1—Throttle steam rate, Units 10 and 11, Long Beach Steam Station. Throttle steam pressure, 400-lb. gage; throttle steam temperature, 725 deg. F.; absolute pressure in condenser as shown

20,000-sq.ft., single-pass, vertical-surface condensers, and two circulating-water pumps, with a combined capacity of 165,000 gal. per min.

Complete condenser performance records over several years' operation at the Long Beach steam station, have revealed many difficulties in obtaining consistent data. These inconsistencies have from time to time occasioned intensive studies of the conditions which cause them. Some of the factors which have been found to affect appreciably the readings are avoided or, if this is not possible, are allowed for by curves constructed from either test or operating data. It is now believed that all the factors which have caused discrepancies in the records are fairly well known and apparent inconsistencies occurring now are due either to inaccuracies in the instruments, such as thermal lag of the injection-water thermometer and location of vacuum-gage connection, or some other cause over which we have no control, as for example, quick changes in load when the unit is used on regulation. In any event, there are so many conditions that must be accurately known that some inconsistent results are to be expected.

The main purpose of keeping condenser performance records is to effect a saving by improving plant efficiency. One of the largest preventable losses in condenser operation and maintenance is the uneconomical balance between the cost of the loss of vacuum due to dirty condensers and the cost of cleaning the condensers. In most plants the condensers are either cleaned too frequently or not often enough. Also in most plants it is impossible to keep the condensers always in a clean condition. The loss in vacuum due to dirty condensers in a large plant involves the expenditure of thousands of dollars yearly. On Units 10 or 11, which are identical, a change of 0.1 in. of mercury in back pressure at 100,000-kw. load changes the steam rate about 0.25 per cent. At lower loads the change in steam rate is more than this, as is shown by the steam rate curve in Fig. 1.

A study of the condenser cleaning problem shows that there are two separate questions that must be studied: (1) the most economical cleaning method, and (2) the most economical interval between cleanings. The first of these is a research problem and before the methods are actually used in practice, involves a good deal of experimentation to determine such factors as: (a) improvement in heat transfer, (b) uniformity of cleaning, (c) effect on tube life. The second is of necessity determinable only from accurate daily condenser performance records and their correct interpretation. In either case there must be some means of judging the condition of the condenser from day to day and the result obtained by cleaning.

A good place to start is with the condenser manufacturer's guaranteed performance, referring all readings to the guaranteed curve as standard or expected operation. Inasmuch as the amount of steam condensed per hour under different operating conditions depends upon turbine characteristics, these should be determined by test, as well as the quantity of circulating water delivered by the pumps. Lacking accurate test data with regard to turbine and pumps, the manufacturer's guarantees may be used and checked later with results obtained in operation.

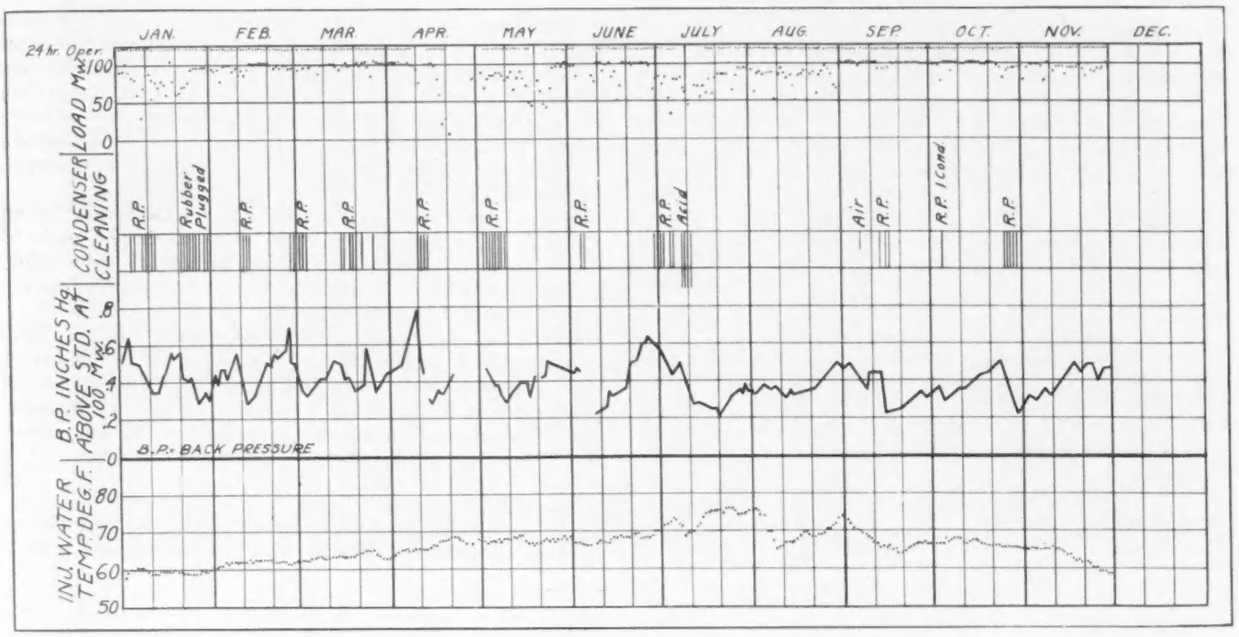


Fig. 2—Record of condenser operation for 1931, Unit 10, Long Beach Steam Station.

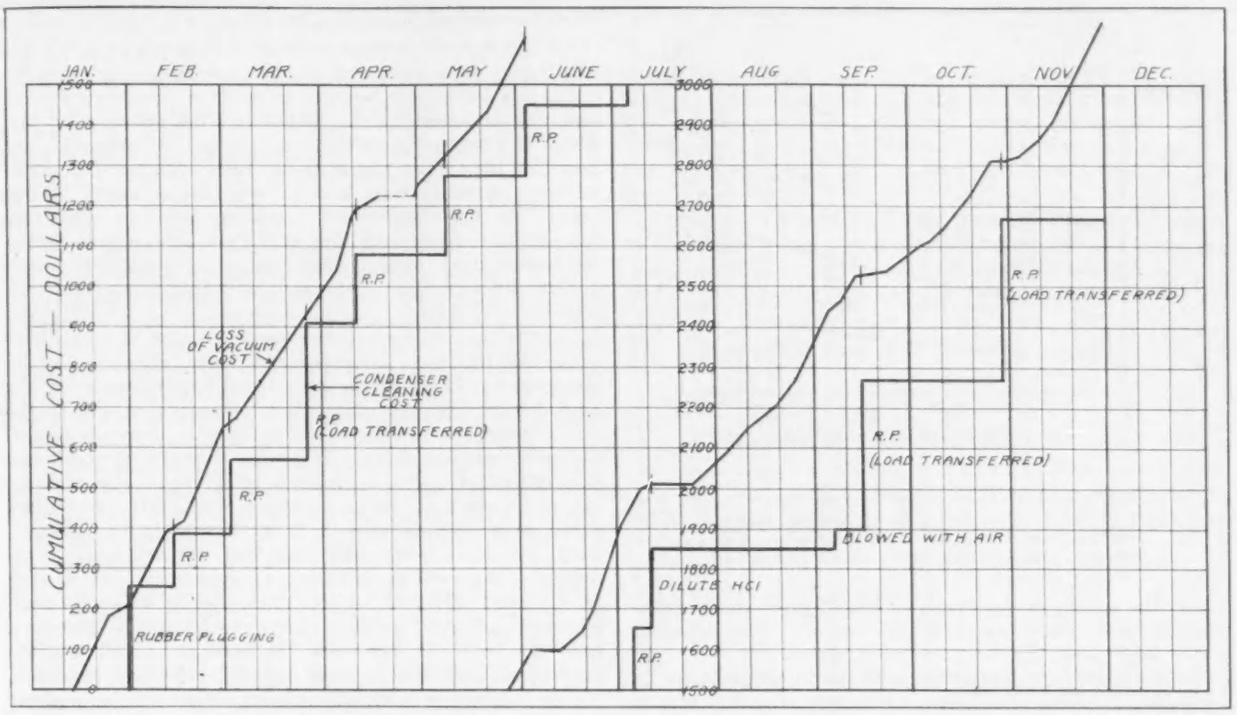


Fig. 3—Record of condenser costs for 1931, Unit 10, Long Beach Steam Station

In considering which data should be used in the calculations, it was at first thought best to use daily average back-pressure readings, as being less subject to error and more representative of actual operating conditions. Undeniably this is a strong argument and has decided advantages, but after plotting several months as an experiment, it was found that, although the back-pressure curve was somewhat smoother than when using spot readings, it still contained apparent inconsistencies that could not be definitely explained. It took considerably more time to plot, as the portions of the day when one or two pumps were operating had to be separately calculated. For the cost-of-loss-of-vacuum curve, perhaps, the most accurate procedure would be to divide the day into periods during which approximately equal load was on the machine and to calculate these separately, but this would require too much time.

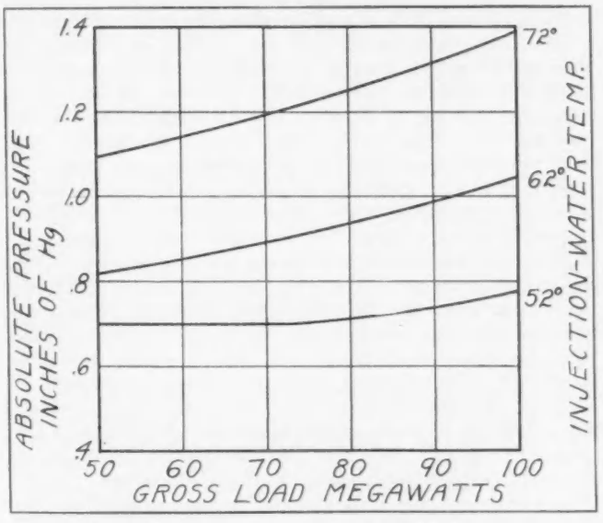


Fig. 4—Absolute pressure in condenser with two cooling-water pumps and 165,000 gal. per min. of ocean water, Units 10 and 11, Long Beach Steam Station

Condenser Log Charts—

Figs. 2 and 3 are typical condenser yearly log charts. The values plotted and the methods of calculation are as follows:

(a) The back-pressure curve (heavy line in Fig. 2) gives the daily difference between the actual back pressure in the condenser and the standard back pressure corrected to the same nominal load of 100,000 kw. The standard back pressure (see Fig. 4) is based on the manufacturer's guarantee for the load at which the reading was taken and the injection-water temperature at that time.

The difference in back-pressure curve (Fig. 5), actual minus guaranteed, might be termed the loss in vacuum curve below guaranteed performance at 100,000-kw. load. It is computed from single daily readings, either observed or taken from the turbine log sheets. Whenever possible the readings are taken under constant-load conditions, at or near 100,000-kw. load. Great care is used when obtaining the actual back pressure, injection-water temperature, and load. Some of the things that are particularly watched and avoided if possible are:

1. Quick changes in load.
2. Quick changes in temperature of injection water.
3. Excessive air leakage.
4. Condenser out for cleaning.
5. Non or partial extraction for feedwater heating.
6. Backwashing condensers.
7. One pump operation, unless the average load is below 55,000 kw.
(A different set of curves is used for one pump operation.)
8. Turbine running at maximum capacity.
9. Condition of intercoolers.

This curve is the yardstick used in judging the cleanliness of the condensers, the daily rate of increase in back pressure, and in estimating the gain by cleaning as well as in comparing the results obtained by different cleaning methods.

(b) The cost curve (broken line) gives the loss of fuel in dollars due to the difference in back pressure between actual and guaranteed at the average load for the day. For the sake of clearness, this curve is not shown in Fig. 2. The difference in back pressure between actual and guaranteed is corrected to the average load for the day, using Fig. 5, before the cost is obtained from the graph in Fig. 6.

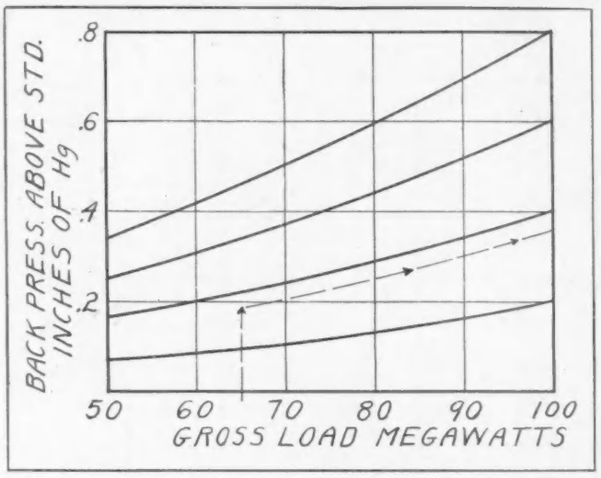


Fig. 5—Correction of absolute pressure in condenser to 100 mw. load. Units 10 and 11, Long Beach Steam Station. Example: Load 65 mw., back pressure 0.19 in.Hg above guarantee. Corrected to 100 mw. which is 0.36 in.Hg above guarantee

(c) The upper, dotted curve of Fig. 2 gives the average load during the operating period of each day. This information is taken from the daily operating report.

The daily average temperature of the injection water is shown by the dotted curve at the bottom of Fig. 2. This is taken from the efficiency card records and is a straight average of the readings taken every two hours.

The straight vertical bars showing the day and how the condenser was cleaned are derived from information taken from the condenser foreman's log books.

Each day of 24-hr. continuous operation is shown by a dot at top of the chart. (Fig. 2.)

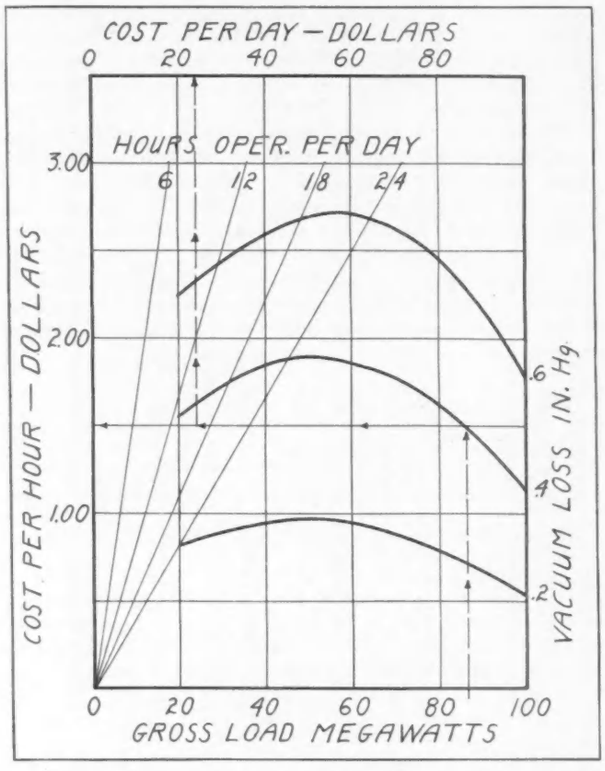


Fig. 6—Cost of low vacuum, with two cooling water pumps, Units 10 and 11, Long Beach Steam Station, Southern California Edison Co. Ltd. Example: Load 86.5 mw., vacuum loss 0.4 in.Hg. Cost per hour is $1.50, cost per day for 16-hour operation is $24

Most Economical Time for Cleaning—

To determine the most economical time for cleaning the condensers, it is necessary to have a correct cost basis for estimating the loss in fuel due to poor vacuum below a clean and tight condenser. This brings up the question of just where to start to figure the cost. In our computations, the base-line for rubber plugging has been taken as 0.25 in. of mercury above standard back pressure for a load of 100,000 kw. This was determined from our previous condenser records and represents the back pressure obtainable at 100,000-kw. load under normal operating conditions immediately after all four condensers have been rubber-plugged, with the unit down.

Usually the condensers are cleaned with the unit in operation. One condenser is cut out each night, when the load on the turbine is 75,000 kw. or less. Occasionally, because of the load demands on the plant, it is necessary to spread the cleaning-out over a longer period. Under these conditions, the condensers are getting dirty while they are being cleaned. Theoretically it would be possible to so extend the cleaning, taking only a part of a condenser each night, that there would be no loss or gain in vacuum—that is, the cleaning would be done at the same rate that the condensers were fouling. The point is that when a condenser is cleaned over an extended period of several days, during which the unit has been operated, the loss of vacuum should be measured from the base-line that would be obtained had all the condensing equipment been taken out of service and cleaned.

This base-line will be different for other cleaning methods and will vary somewhat with condition of plugs, scale on tubes, and may be affected by large changes in temperature of the circulating water.

The method of calculating the loss in dollars per day due to the back pressure being above the rubber-plug base-line is as follows:

1. The difference between actual and standard back pressure obtained for the spot reading is corrected to the average load for the day by using Fig. 5.
2. The 0.25 in. of mercury at 100,000 kw. (base-line for rubber plugging) is also corrected to the average load for the day, using the same curve (Fig. 5) and subtracted from the result obtained in (1).
3. The result obtained in (2) is converted to dollars by Fig. 6.

The daily values are plotted cumulatively in Fig. 3 to obtain the cost of loss of vacuum below a clean and tight condenser. When the cumulative cost from the last cleaning reaches the average cleaning cost of rubber plugging, it is time to clean, provided it is not necessary to transfer load to a less efficient unit. When this is necessary, the cleaning is not done until it is economical to do it. This requires that a very close watch be kept of the expected load demand as well as the condition of the condensers. Occasionally it is more economical to clean a few days ahead of time or to delay the cleaning as much as a week, rather than transfer load from No. 3 to No. 2 plant. Because of this it is very hard to obtain an exact balance between the two costs. The most that can be hoped for is an intelligent approximation, which is probably as close as the actual costs are known. It should be understood that the differences between each cleaning cost and the corresponding loss due to poor vacuum are not the amounts that could be saved, even if it were possible to keep the two the same, because to lower the vacuum loss, the cleaning has to be done oftener, which would increase the cleaning cost. Also it should be emphasized that each period must be considered separately and that the difference between the total costs for the year is not indicative of how systematically the cleaning has been done. The interval taken at this plant is from a clean condenser to the completed cleaning of the condenser.

As mentioned above, against the loss due to back pressure above the rubber-plug base-line, should be balanced the cost of cleaning the condensers by rubber plugs. This cost includes:

1. The cost of labor, taken from the time cards.
2. The cost of material, estimated from the 1930 records to be $10 per cleaning.
3. The cost of transferring load from No. 3 to No. 2 plant. This has been calculated to be $8 per hour for 25,000 kw.
4. The drop in vacuum when one condenser is cut out to be cleaned while the unit is in operation. This was determined to be about $10 per cleaning period of 24 hr., which is about the time necessary to clean all four condensers.

Derivation of Curves

Figure 4—When the guaranteed performance is used for reference, the construction of the curves is quite simple. Usually the condenser manufacturer, who has been furnished information regarding the turbine characteristics, guarantees specified back pressures in the condenser opening under normal operation with stated amounts of circulating water at different temperatures, covering the range of conditions that would be expected in operation. These data are given for various stated quantities of steam to the condenser, which cover the normal operating range of the turbine. When load is plotted against back pressure, as in Fig. 4, all that is required is a curve regarding turbine operation showing the relation between lb. of steam to the condenser, and the kw. generated, such as shown in Fig. 7.

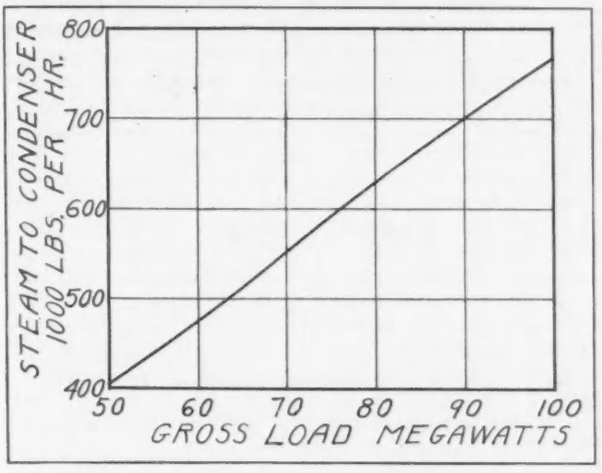


Fig. 7—Steam to condenser for full extraction operation, Units 10 and 11, Long Beach Steam Station

Obtaining the relation between kw. and steam to the condenser from this curve and using the manufacturer's guaranteed back pressures given in Table I, the construction of the curves in Fig. 4 is seen to be a very simple procedure. Actually these curves were obtained as explained below under condenser calculations.

TABLE I—Guaranteed Back Pressures Units 10 or 11 With 165,000 gal. per min., 41,250 gal. per min. to Each Condenser.

Steam Condensed Lb. per hr.		Injection-water Temperatures Deg. F. 52	62	72
760,000	Back Pressure In. Hg.	0.77	1.03	1.37
680,000	Back Pressure In. Hg.	0.73	0.97	1.30
560,000	Back Pressure In. Hg.	0.70	0.90	1.20
440,000	Back Pressure In. Hg.	0.70	0.83	1.11

Figure 5 was prepared from data taken from the operating records. Days were selected when the turbine had been operated at various blocked loads. The difference in back pressure, actual minus guaranteed, was plotted for each load. A smooth curve was drawn through each day's points. A sufficient number of days were taken to establish an average curve for each degree of condenser cleanliness, from a clean to a dirty condenser. This curve was also checked with data obtained in the turbine test.

Lacking operating data for establishing this curve, an approximate correction for load curve can be calculated by use of the straight-line law, that is, doubling the steam flow to the condenser doubles the temperature difference between the exhaust steam and injection water. (Fig. 10). This difference, added to the injection water temperature, gives the temperature of the exhaust steam and therefore the back pressure.

Figure 6—To prepare a cost curve for loss of vacuum, it is necessary to know as accurately as possible the operating characteristics of the plant. If practicable, a curve such as shown in Fig. 8 should be made for the over-all efficiency

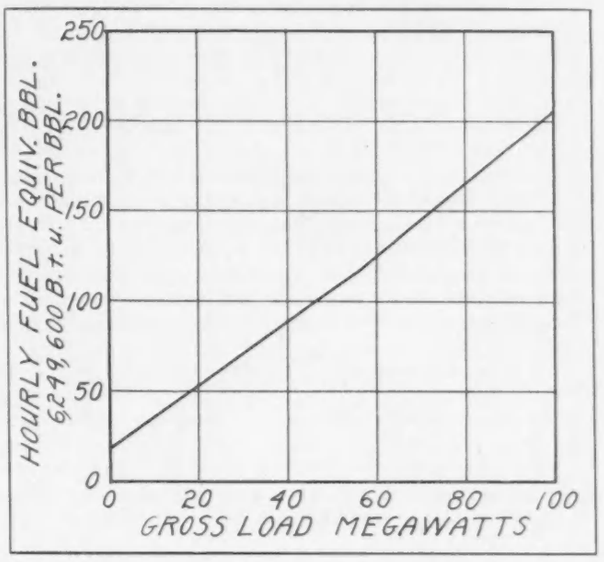


Fig. 8—Hourly fuel economy characteristics, Units 10 and 11, Long Beach Steam Station

of the turbine and boilers from actual operating records. Using the steam rate curve in Fig. 1, the per cent correction of the steam rate for a loss in vacuum of 0.1, 0.2, 0.3 in. of mercury can be determined for a number of loads. These percentages, applied to the fuel economy curve (Fig. 8), will give the B.t.u. lost for each load. Finally, it is only necessary to know the cost of the B.t.u. in dollars, to construct the curves in Fig. 6 from these values.

Condenser Calculations

Heat Transfer Fodmula—For proper interpretation of condenser performance or guarantees it is necessary to have an understanding of certain condenser calculations. Also it may be necessary to recalculate or modify the manufacturer's guarantees, because of some change in the conditions as found in operation from what was assumed when the guaranteed performance was calculated.

The fundamental equation of the surface condenser is:

$$S = \frac{950\ P}{U\ D}$$

in which

S = sq.ft. of tube surface in the condenser.

P = lb. of steam per hr. to be condensed.

950 = heat per lb. of exhaust steam to be abstracted by the condenser. (This is an approximate figure; exact values may be determined by allowing for the thermal efficiency of the turbine.)

D = logarithmic mean temperature difference between the steam and circulating water. It may be taken from tables or charts or calculated from

$$D = \frac{T_2 - T_1}{\log_e \frac{Ts - T_1}{Ts - T_2}}$$

Ts = temperature of the steam at a given vacuum, obtainable from the steam tables,

T_1 = temperature of inlet water, and

T_2 = temperature of outlet water.

U = the coefficient of heat transfer, is the amount of heat transmitted per sq.ft. of surface per degree mean temperature difference per hour. The coefficient depends upon a number of factors, among which are the following:

(a) *The condition of the tube surface*—A rough surface, or a thin coating of scale or slime will have a large effect upon the value of U.

(b) *Air leakage*, which lowers the coefficient.

(c) *Size of tubes*—Smaller tubes have a greater surface in proportion to their volume than large tubes and heat is transferred more easily.

(d) *Water velocity*—Increased water velocity increases the turbulence within the tube and thus aids heat transfer.

(e) *Water temperature*—Cold water is more viscous than warm water and produces a lower heat-transfer coefficient.

(f) *Loading*—The amount of steam condensed per sq.ft. of cooling surface should be taken into account, especially when the expected condenser performance is being calculated over a wide variation in turbine capacity.

(g) *Vacuum*—High vacuum not only makes it more difficult to remove non-condensable gases due to greater volume, but also lowers the heat transfer coefficient by decreasing the condenser temperature.

(h) *There are a number of other factors*, such as material in tubes, size and shape of condenser, tube spacing, etc., all of which may be summed up as the details of condenser design and air removal apparatus.

Aside from the condition of the tube surface, the determination of which is the main reason for keeping condenser performance records, usually the only other variables entering into the calculations after the condenser is in operation are: (1) water velocity, (2) water temperature, and (3) loading (lb. of steam per sq. ft. of cooling surface). The effect of the latter two factors on the coefficient of heat transfer is shown in Fig. 9.

Ordinarily it is commercial practice to consider 70 deg. F. circulating water and 8 lb. of steam per sq. ft. of cooling surface as standard conditions in condenser calculations. Also for normal conditions, where there is plenty of 70 deg. F. water available, the terminal difference (temperature difference between exhaust steam and outlet water) is taken as 17 deg. F. for a vacuum of 28 in. of mercury.

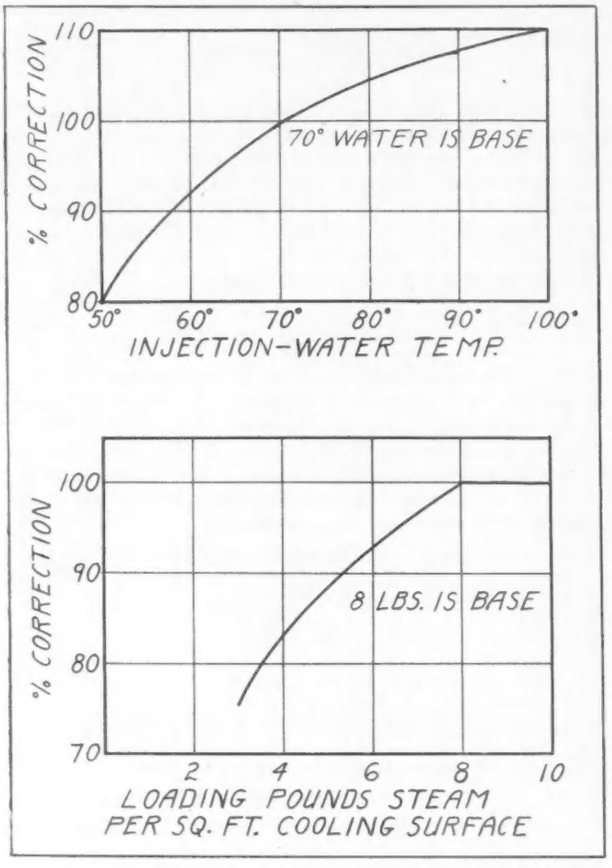


Fig. 9—Coefficient of heat transfer correction factors

It should be mentioned that the smaller the terminal difference, the greater will be the surface required for a given vacuum and the higher the initial cost of the condenser. On the other hand, with a small terminal difference, less water is required than with a large terminal difference, and vice versa.

Circulating Water Quantity. The amount of circulating water used in the condenser may be calculated from the equation:

$$G = \frac{950\ P}{500\ (T_2 - T_1)} \qquad (3)$$

where,

G = gal. per min. of circulating water.

P = lb. of steam condensed per hr.

T_1 = initial temperature of cooling water.

T_2 = final temperature of cooling water.

500 = constant for changing gal. per min. into lb. per hr.

950 = the heat abstracted per lb. of exhaust steam. This should be determined for each turbine, by taking into account its thermal efficiency.

This equation may be used to determine the gallons of water going to the condenser when the temperatures are known, or it may be used to calculate the temperature rise when the water quantity is known. A very accurate determination of the temperature difference can be made with resistance thermometers and looped leads to compensate for temperature variations of the thermometer lead wires.

Variations of Water Quantity—It may be found by test that the circulating-water pumps deliver more or less water than was assumed in the calculation of the guaranteed condenser performance. Or it might be required to find what vacuum would be obtained by driving the pump at a lower speed, or by using only one pump where two are provided. Reduced water quantity has two effects: First, the rise in water temperature necessary to absorb the heat is increased, as shown in equation (3), and consequently the mean water temperature is raised. Second, the coefficient of heat transfer varies approximately in proportion to the square root of the quantity of water (water velocity). For example, it is desired to change the guaranteed back pressure given in Table I for 760,000 lb. of steam per hr., 72 deg. F. water and 165,000 gal. per min. to the same conditions with only 150,000 gal. per min. of circulating water.

Transposing equation (3):

$$T_2 - T_1 = \frac{950 \times 760{,}000}{500 \times 165{,}000} = 8.75 \text{ deg. F}$$

Inlet water temperature = 72 deg. F.

Outlet water temperature = 72 + 8.75 = 80.75 deg. F.

Exhaust steam temperature = 89.15 deg. F. (1.37 in. Hg. back pressure).

$$D = \frac{80.75 - 72}{\log_e \dfrac{89.15 - 72}{89.15 - 80.75}} = 12.2$$

For the reduced quantity of circulating water the coefficient of heat transfer will be decreased in the ratio $\sqrt{\frac{150{,}000}{165{,}000}}$ so to transfer the same amount of heat across the same surface the mean temperature difference must be increased in the ratio $\sqrt{\frac{165{,}000}{150{,}000}}$ or 1.05. The new mean temperature difference is:

$$1.05 \times 12.2 = 12.8$$

The temperature rise with the reduced quantity of circulating water will be:

$$T_2 - T_1 = \frac{950 \times 760{,}000}{500 \times 150{,}000} = 9.62$$

The terminal difference, 8.5 is obtained from a logarithmic

mean-temperature-difference chart for a temperature rise of 9.6 and mean temperature difference of 12.8. The initial temperature difference between exhaust steam and injection water is obtained by adding the terminal difference to the temperature rise. In this case it is:

$$8.5 + 9.6 = 18.1$$

which, added to the injection water temperature (72 deg.) gives the exhaust steam temperature equal 90.1 deg. F. The steam tables show this to correspond to a back pressure of 1.42 in. of mercury.

This indicates the general procedure to be followed in condenser calculations.

Straight Line Law—Fig. 10 shows the relation between the straight-line law, as developed in the 1924 N.E.L.A. report on condensers, and the guaranteed performance of Units 10 or 11.

The straight-line law was used in checking Fig. 5, which was derived from actual operating data. The points taken checked very closely.

The condenser records of Units 10 or 11 show that the actual performance comes closer to the guaranteed curves at lower loads and lower injection-water temperatures. A partial traverse has been made of the differences in pressure in the condenser opening. Appreciable differences were found and it may be that by changing our vacuum-gage connections to conform to the best accepted practice, we may more nearly approach the guaranteed performance. We intend to make this change, as soon as load conditions permit Unit 11 to be down for a short time.

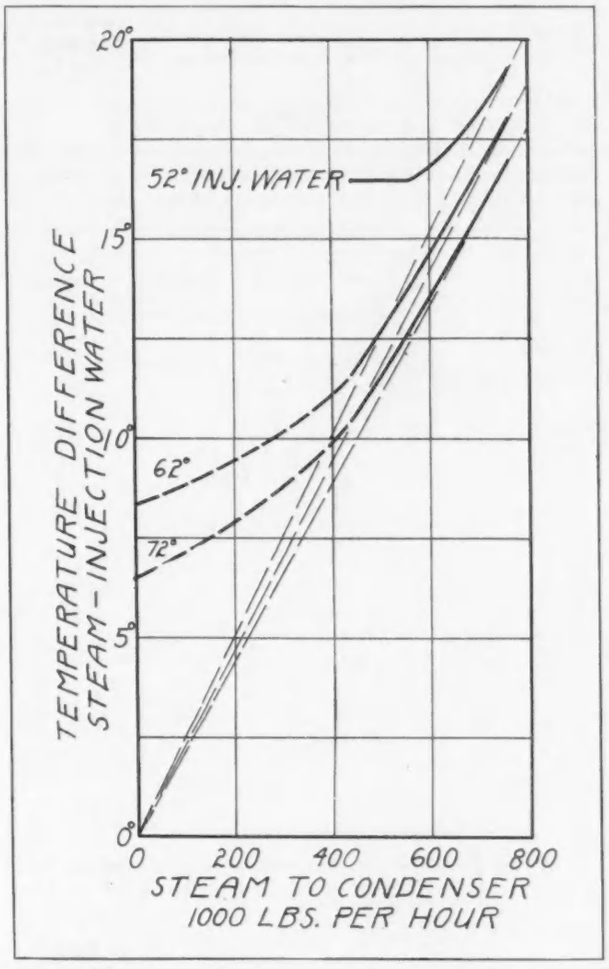


Fig. 10—Relation between straight-line low and guaranteed performance, Units 10 and 11, Long Beach Steam Station

*Piping Design Features of Station A**

This report has been prepared by C. E. Steinbeck of the Pacific Gas and Electric Company and contains material derived from the design of Station "A", the 1,400-lb. pressure, 750-deg. F. plant of that company in San Francisco. Some of the special features used in this design are given and a discussion is added in connection with various features of design and construction which it is thought will be of interest.

Pipe

SEAMLESS steel tubing was used for the high-pressure steam and the reheat steam lines, the 12-in. high-pressure tubing being 1.21875 in. thick and the 14-in. and 20-in. reheat piping being 0.500 in. and 0.625 in. respectively. This tubing was all grade B, manufactured in accordance with A.S.T.M. Tentative Specification A-106-28-T. Seamless steel tubing was also used on all piping subject to high pressure such as boiler blow-off, drain lines, steam-flow meter lines, etc. The usual standard pipe was used for all low-pressure service.

Flanges

In order to avoid confusion in designating measurements of flanges, drawings were prepared, illustrated by Figs. 1 and 2, specifying what was meant by each item.

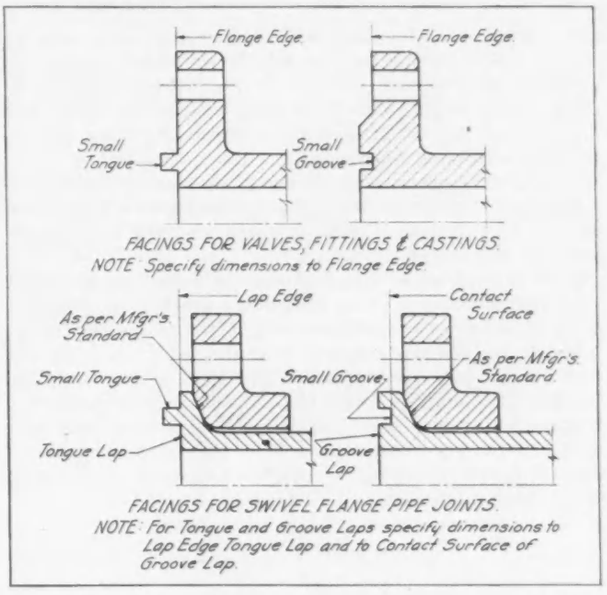

Flange Edge
Flange Edge
Small Tongue
Small Groove
FACINGS FOR VALVES, FITTINGS & CASTINGS.
NOTE: Specify dimensions to Flange Edge.
Lap Edge
Contact Surface
As per Mfgr's Standard
As per Mfgr's Standard
Small Tongue
Small Groove
Tongue Lap
Groove Lap
FACINGS FOR SWIVEL FLANGE PIPE JOINTS.
NOTE: For Tongue and Groove Laps specify dimensions to Lap Edge Tongue Lap and to Contact Surface of Groove Lap.

Fig. 1—Types of small torque and small groove pipe joints, Station A, Pacific Gas and Electric Co.

It was felt that the flange thicknesses, specified in the A.E.S.C. standards for 1,350 lb., were not sufficient, and as a consequence all forged-steel pipe flanges and flanges on valves and fittings for this pressure were made in accordance with Table I. All dimensions for other flanges were as per A.E.S.C. standards, with material as per A.S.T.M. Specifications A-105-28.

A great many small flanges were used on meter piping, drain piping and the like, and here it was found necessary, in order to use the proper size of seamless tubing and to maintain the maximum strength, to design special flanges. These designs are as illustrated in Figs. 3, 4, and 5. For these small sizes the small tongue-and-groove have not proved

* Report of subcommittee on station piping, prime movers committee, Engineering Section. C. E. Steinbeck, chairman. A. K. Ingraham, F. R. Knight, H. N. Mosher, F. G. Philo, W. H. Short.

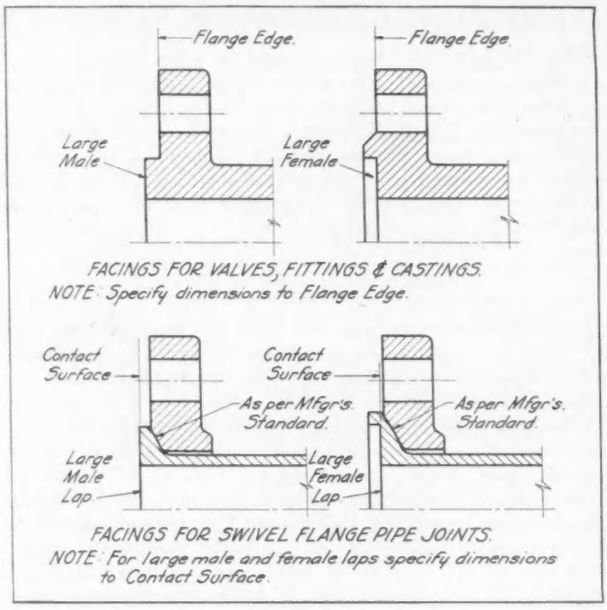

Flange Edge.
Flange Edge.
Large Male
Large Female
FACINGS FOR VALVES, FITTINGS & CASTINGS.
NOTE: Specify dimensions to Flange Edge.
Contact Surface
Contact Surface
As per Mfgr's. Standard.
As per Mfgr's. Standard.
Large Male Lap
Large Female Lap
FACINGS FOR SWIVEL FLANGE PIPE JOINTS.
NOTE: For large male and female laps specify dimensions to Contact Surface.

Fig. 2—Types of large male and large female pipe joints, Station A, Pacific Gas and Electric Co.

as satisfactory as the large male and female. The tongues are so small that it is very easy for a workman erecting the piping to exert enough pressure on the bolting to crush the metal in the tongue, with a resulting leak in the joint.

The protection of flanges in shipment is a very serious problem, which has not been given proper attention by equipment manufacturers. As a result of this lack of care, scratches and nicks in flange facings have caused manufacturers many thousands of dollars and erectors much inconvenience and loss of time.

Various methods of flange protection were used by equipment manufacturers. One used for protection of "Sarlun" faces consisted of a cast-iron cover bolted to the flange and raised in the center enough to clear the joint face. The design of this cover was good, except that it was made too light and two or three broke in shipment, causing damage to the face. Had they been made of steel or heavier cast iron, very satisfactory results would have been obtained. Heavy wooden protectors bolted to tongue-and-groove flanges give satisfactory protection.

TABLE I

Nominal Pipe Size	Body of Fitting		Flange		Dia of Bolt C	No. of Bolts	Size of Bolts	A	C	E	F	G
	Inside Dia	Min. Metal Thickness	Outside Dia	Thickness				Center to Flg. Edge, Ells, Tees & Crosses	Center to Flg. Edge, 45° Ells.	Long Center to Flg. Edge, Laterals	Short Center to Flg. Edge, Laterals	Flg. Edge to Flg. Edge, Reducer
1	1	3/8	5 1/2	1 1/8	4	4	3/4	5	3 1/2	9	2 1/2	5
1 1/4	1 1/4	3/8	6 1/4	1 1/8	4 1/8	4	3/4	5 1/2	4	10	3	5 1/2
1 1/2	1 1/2	7/16	7	1 1/4	4 3/4	4	1	6	4 1/2	11	3 1/2	6 1/2
2	1 7/8	1/2	8 1/2	1 1/4	6 1/2	8	3/4	7 1/2	4 1/2	13 1/2	4 1/2	7 1/2
2 1/2	2 3/4	5/8	9 1/2	2	7 1/2	8	1	8 1/2	5 1/2	15 1/2	4 1/2	8 1/2
3	2 3/4	11/16	10 1/2	2 1/4	8	8	1 1/8	9 1/2	5 1/2	17 1/2	5 1/2	9 1/2
3 1/2	3 1/2	13/16	11	2 1/2	8 1/2	8	1 1/8	10	6 1/2	18 1/2	5 1/2	10 1/2
4	3 1/2	7/8	12 1/2	2 1/2	9 1/2	8	1 1/2	11	7 1/2	19 1/2	6 1/2	11 1/2
5	4 1/2	1 1/16	14 1/2	2 1/2	11 1/2	8	1 1/2	13	8 1/2	23	7 1/2	13 1/2
6	5 1/2	1 3/16	15 1/2	3 1/2	12 1/2	12	1 1/2	13 1/2	9	24 1/2	7 1/2	13 1/2
8	7	1 1/2	19	3 1/2	15 1/2	12	1 1/2	16 1/2	10 1/2	29 1/2	8 1/2	16 1/2
10	8 1/2	1 9/16	23	4 1/2	19	12	1 1/2	19 1/2	11 1/2	35 1/2	10	19 1/2
12	10 1/2	2 1/8	25 1/2	5	21 1/2	16	1 1/2	20 1/2	12 1/2	38 1/2	11 1/2	21 1/2
14	11 1/2	2 5/8	27 1/2	5 1/2	23 1/2	16	2	21 1/2				21 1/2

NOTE: For forged steel valves and fittings use A.E.S.C. Std. of June 1927

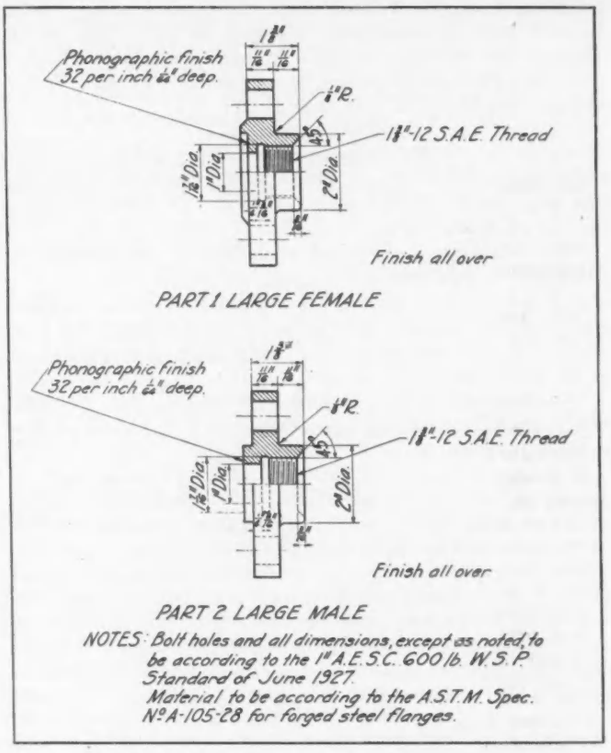


Fig. 3—Detail of 1-in. large male and large female flanges for 600-lb. pressure, Station A, Pacific Gas and Electric Co.

Joints

All joints in the 1,350-lb. piping were of the Sarlun type and were made in accordance with Fig. 6. Before erection, great care was taken to see that the smooth finish on the

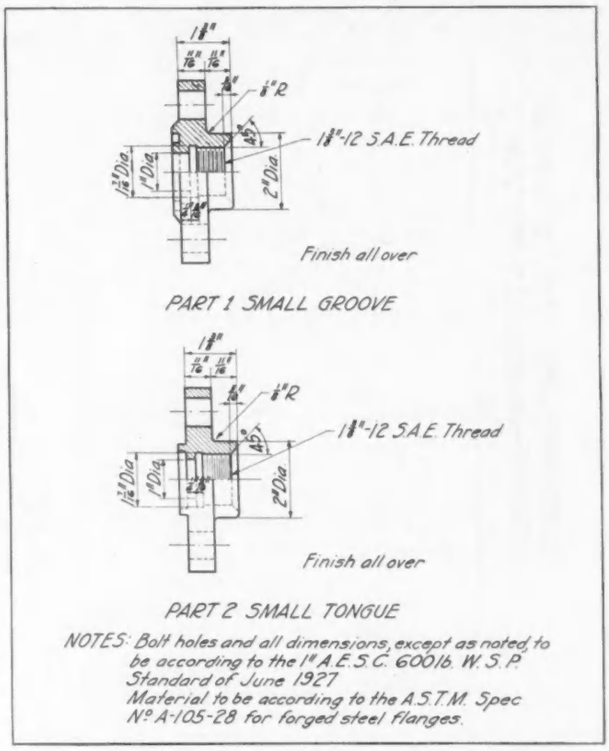


Fig. 4—Detail of 1-in. small torque and small groove flanges for 600-lb. pressure, Station A, Pacific Gas and Electric Co.

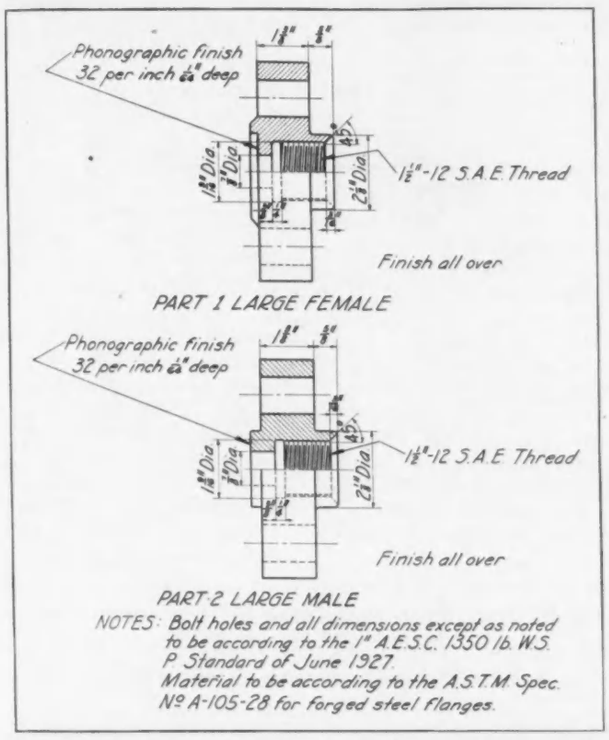
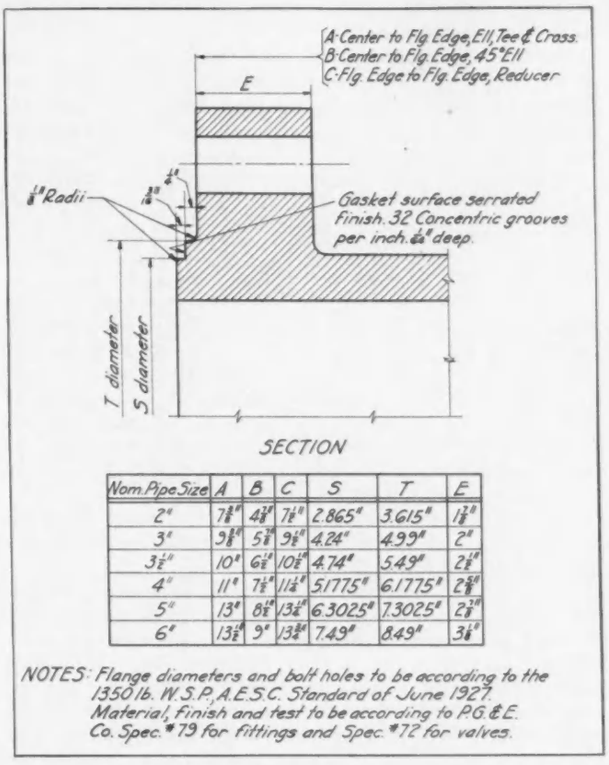

Phonographic finish
32 per inch deep
1½"-12 S.A.E. Thread
Finish all over
PART 1 LARGE FEMALE
Phonographic finish
32 per inch deep
1½"-12 S.A.E. Thread
Finish all over
PART 2 LARGE MALE
NOTES: Bolt holes and all dimensions except as noted to be according to the 1" A.E.S.C. 1350 lb. W.S.P. Standard of June 1927.
Material to be according to the A.S.T.M. Spec. No. A-105-28 for forged steel flanges.

Fig. 5—Detail of 1-in. large male and large female flanges for 1,350-lb. pressure, Station A, Pacific Gas and Electric Co.

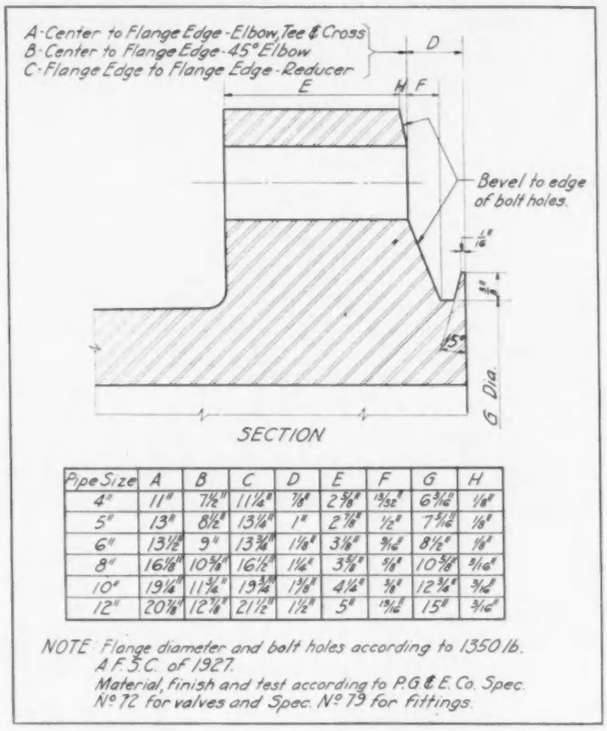

A-Center to Flg. Edge, Ell, Tee & Cross.
B-Center to Flg. Edge, 45° Ell
C-Flg. Edge to Flg. Edge, Reducer
Gasket surface serrated finish. 32 Concentric grooves per inch deep.
SECTION

Nom. Pipe Size	A	B	C	S	T	E
2"	7⅞"	4¾"	7½"	2.865"	3.615"	1⅞"
3"	9⅛"	5⅞"	9½"	4.24"	4.99"	2"
3½"	10"	6½"	10½"	4.74"	5.49"	2⅛"
4"	11"	7⅛"	11½"	5.1775"	6.1775"	2⅜"
5"	13"	8½"	13¾"	6.3025"	7.3025"	2⅞"
6"	13½"	9"	13¾"	7.49"	8.49"	3⅛"

NOTES: Flange diameters and bolt holes to be according to the 1350 lb. W.S.P. A.E.S.C. Standard of June 1927.
Material, finish and test to be according to P.G.&E. Co. Spec. #79 for fittings and Spec. #72 for valves.

Fig. 7—Detail of male stepped joint for 1,350-lb. pressure, Station A, Pacific Gas and Electric Co.

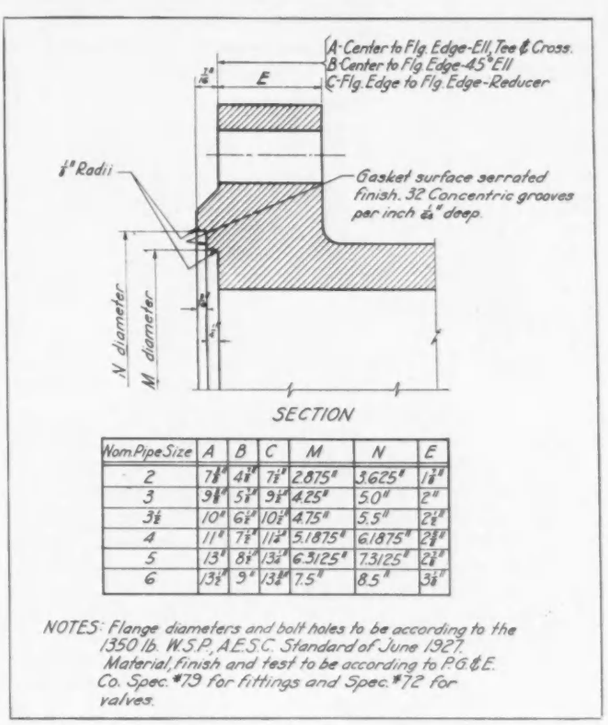
faces of these joints was as perfect as it was possible to make it. Tests were made before erection by bolting sections of the piping together and applying a hydrostatic pressure of 2,500 lb. per sq. in. It was found that small leaks occurred in several joints, and upon examination, minute scratches extending the full length of the faces accounted for some of these leaks. A face plate was next used and a number of faces were found to have high spots. It was decided that it would be very good insurance to examine every face with the aid of the face plate and to scrape the surface


A-Center to Flange Edge-Elbow, Tee & Cross
B-Center to Flange Edge-45° Elbow
C-Flange Edge to Flange Edge-Reducer
Bevel to edge of bolt holes.
SECTION

Pipe Size	A	B	C	D	E	F	G	H
4"	11"	7½"	11¼"	⅞"	2 5/16"	13/32"	6 3/16"	1/16"
5"	13"	8½"	13¼"	1"	2 7/8"	½"	7 5/16"	1/8"
6"	13½"	9"	13¾"	1⅛"	3⅛"	9/16"	8½"	1/8"
8"	16⅛"	10 5/16"	16½"	1¼"	3⅝"	5/8"	10 3/8"	5/16"
10"	19¼"	11¾"	19¾"	1⅜"	4¼"	⅝"	12 3/4"	3/8"
12"	20⅞"	12 7/8"	21½"	1½"	5"	13/16"	15"	3/16"

NOTE: Flange diameter and bolt holes according to 1350 lb. A.F.S.C. of 1927.
Material, finish and test according to P.G.&E. Co. Spec. No. 72 for valves and Spec. No. 79 for fittings.

Fig. 6—Dimensions of flanges used for welded joints for 1,350-lb. pressure, Station A, Pacific Gas and Electric Co.


A-Center to Flg. Edge-Ell, Tee & Cross.
B-Center to Flg. Edge-45° Ell
C-Flg. Edge to Flg. Edge-Reducer
Gasket surface serrated finish. 32 Concentric grooves per inch deep.
SECTION

Nom. Pipe Size	A	B	C	M	N	E
2	7⅞"	4¾"	7½"	2.875"	3.625"	1⅞"
3	9⅛"	5⅞"	9½"	4.25"	5.0"	2"
3½	10"	6½"	10½"	4.75"	5.5"	2⅛"
4	11"	7⅛"	11½"	5.1875"	6.1875"	2⅜"
5	13"	8½"	13¾"	6.3125"	7.3125"	2⅞"
6	13½"	9"	13¾"	7.5"	8.5"	3⅛"

NOTES: Flange diameters and bolt holes to be according to the 1350 lb. W.S.P. A.E.S.C. Standard of June 1927.
Material, finish and test to be according to P.G.&E. Co. Spec. #79 for fittings and Spec. #72 for valves.

Fig. 8—Detail of female stepped joint for 1,350-lb. pressure, Station A, Pacific Gas and Electric Co.

as nearly perfect as possible before assembling the piping in its permanent location.

The face of each flange was left 0.003 in. high for a width of approximately 1 in. on the inside edge, so that when bolting up, the deflection of the faces caused them to have a bearing over their entire width. An imprint of each face was obtained and is being kept for future reference.

On some of the contract work installed by manufacturers, 1,400-lb. joints were made, using soft gaskets. If these joints were properly followed up under working pressure and temperature conditions, they proved to be tight. The type of joints used for this work is shown in Figs. 7 and 8.

After all joints were finished in any one section of pipe, a hydrostatic test of 2,500 lb. was applied before welding. In welding, one stud was removed at a time and the sections of the two adjacent studs between the flanges were protected by asbestos, and that section of the welding lip which was exposed by the stud removal was sealed by the oxyacetylene welding. After the welding was completed, the stud was replaced and tightened, and the next one was taken out and the process repeated.

The result of all this care was reflected in the operation of the piping, as not a single joint in the welded piping leaked after being placed in service.

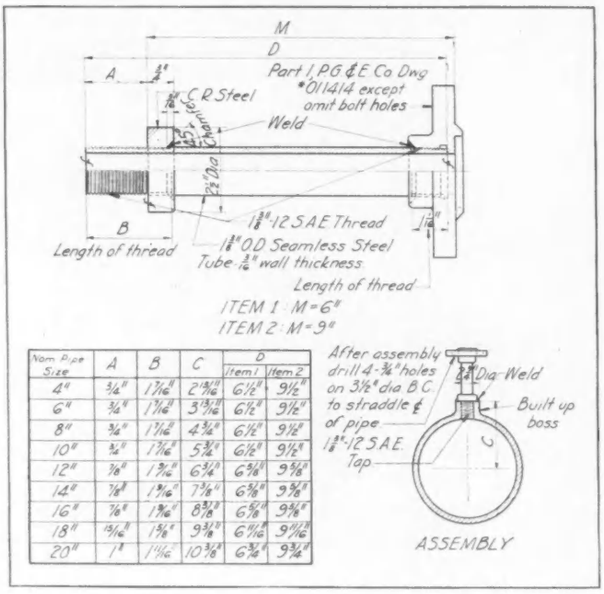
Joints in the reheat piping were all made small tongue-and-groove, to the A.E.S.C standards. Monel gaskets 1/32 in. thick were used in these joints and although they were all tight at first, a few of them had to be replaced, due to leaks which later appeared. Upon removal, the gaskets were found to be cracked. Replacement was made with soft annealed furniture steel gaskets, which have been found to give satisfaction. This annealing is obtained by heating the steel to 850 deg. C. in a hydrogen atmosphere and annealing by slow cooling. This prevents oxidation. These gaskets are No. 22 gage in thickness.

Nipples, Thermometer Wells, Etc.

Where it was necessary to make connections to high pressure piping for drains, special nipple assemblies were designed, as illustrated in Figs. 9 and 10. Thermometer wells were all made special, as indicated on Fig. 11.

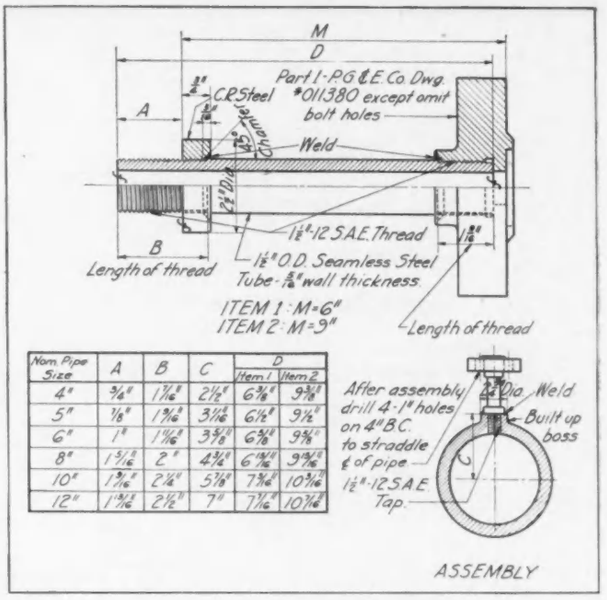
Valves

In the purchase of the larger valves for 600-lb. and 1,350-lb. operation, the following information was requested from manufacturers:



Nom. Pipe Size	A	B	C	D Item 1	D Item 2
4"	¾"	1 7/16"	2 1/16"	6 1/2"	9 1/2"
6"	¾"	1 7/16"	3 13/16"	6 1/2"	9 1/2"
8"	¾"	1 7/16"	4 3/4"	6 1/2"	9 1/2"
10"	¾"	1 7/16"	5 3/4"	6 1/2"	9 1/2"
12"	⅞"	1 9/16"	6 3/4"	6 5/8"	9 5/8"
14"	⅞"	1 9/16"	7 7/8"	6 5/8"	9 5/8"
16"	⅞"	1 9/16"	8 3/4"	6 5/8"	9 5/8"
18"	1 1/16"	1 9/16"	9 3/4"	6 11/16"	9 11/16"
20"	1"	1 1/16"	10 3/4"	6 3/4"	9 3/4"

Fig. 9—Detail of 1-in. flanged nipple for 1,350-lb. pressure, Station A, Pacific Gas and Electric Co.



Nom. Pipe Size	A	B	C	D Item 1	D Item 2
4"	¾"	1 7/16"	2 1/2"	6 3/8"	9 3/8"
5"	⅛"	1 9/16"	3 1/16"	6 1/2"	9 1/2"
6"	1"	1 1/16"	3 5/8"	6 5/8"	9 5/8"
8"	1 5/16"	2"	4 3/4"	6 15/16"	9 15/16"
10"	1 7/16"	2 1/4"	5 7/8"	7 3/16"	10 3/16"
12"	1 9/16"	2 1/2"	7"	7 1/16"	10 7/16"

Fig. 10—Detail of 1-in. flanged nipple for 600-lb. pressure, Station A, Pacific Gas and Electric Co.

(a) Complete description of motor and hand-operating mechanisms.

(b) Chemical analyses of various metals used.

(c) Physical properties of various metals used, including castings and metals used for seat rings and disks, including the following data:

1. Yield point
2. Elongation in 2 in.
3. Reduction of area
4. Brinell hardness
5. Coefficient of expansion 0-600 deg. C.
6. Modulus of elasticity at 70 deg. F. and 750 deg. F.
7. Maximum allowable stress in lb. per sq.in.

For spindles, in addition to the preceding list of properties:

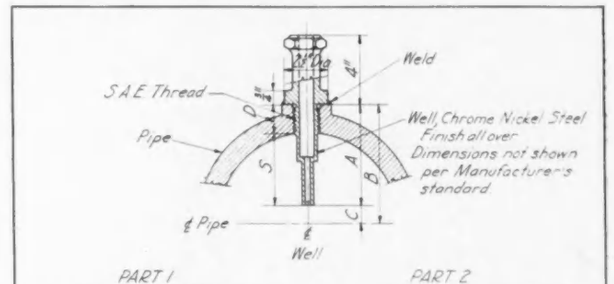
8. Charpy impact
9. Torsion modulus
10. Total angle of twist in 4 in.

(d) Weight.

(e) Time to open and close each kind of valve when operated by motor and amperes required at 125 volts d.c. Pounds pull required on handwheels to close or open valves, under a full unbalanced pressure of 1,700 lb. per sq.in. gage.

(f) List of installations of similar valves and time each has been in service.

(g) Kind of packing used.



PART 1

For 1350 lb W.S.P. 1⅛"-12 Threads					
Nom. Pipe Size	A	B	C	D	S
4"	2 1/8"	2 1/2"	3/16"	3/4"	1 3/8"
5"	2 5/8"	3 1/16"	1/16"	7/8"	1 7/8"
6"	3 1/16"	3 5/8"	3/16"	1"	2 1/16"
8"	4 1/16"	4 3/4"	1 1/16"	1 5/16"	2 7/16"
10"	5"	5 7/8"	1 7/16"	1 5/16"	3 1/16"
12"	6"	7"	1"	1 5/16"	4 1/16"

PART 2

For 600 lb W.S.P. 1⅛"-12 Threads					
Nom. Pipe Size	A	B	C	D	S
4"	2 3/16"	2 15/16"	7/16"	3/4"	1 5/8"
6"	3 1/4"	3 7/16"	9/16"	3/4"	2 1/2"
8"	4"	4 5/8"	3/4"	3/4"	3 1/4"
10"	4 15/16"	5 1/4"	1 1/16"	3/4"	4 1/16"
12"	5 7/8"	6 3/4"	1 1/16"	7/8"	4 3/4"
14"	6 1/8"	7 7/8"	1 1/4"	7/8"	5 1/4"
16"	6 7/8"	8 7/8"	1 1/2"	7/8"	6"
18"	7 3/4"	9 3/4"	1 5/8"	15/16"	6 3/4"
20"	8 1/2"	10 3/4"	1 7/8"	1"	7 1/2"

Fig. 11—Detail of thermometer well for 600-lb. and 1,350-lb. pressure, Station A, Pacific Gas and Electric Co.

(h) Kind of bypass valve used. Drawings showing these valves and methods of connection.

(i) For 1,350-lb. check valves, pressure drop when passing 575,000 lb. of water per hour at 1,700 lb. per sq.in. gage pressure and 460 deg. F. temperature. For 600-lb. check valves, pressure drop when passing 575,000 lb. of water per hour at 700 lb. per sq.in gage pressure and 234 deg. F. temperature.

Valves purchased under these specifications for 1,350-lb. operating pressure were motor-operated in all sizes 8-in. and above, 12-in. being the largest. Only 14-in. and 20-in. 600-lb. valves were motor-operated. All other valves were hand-operated. Motors were designed to operate at 125 volts d.c., but were designed to have ample torque for operation at 80 volts d.c.

All valve castings were specified to be made of electric cast steel, with material conforming to A.S.T.M. Tentative Specification No. A-95-28-T for carbon-steel valves, flanges and fitting castings for high-temperature service, except that no defects were allowed to be welded or plugged. Test pressures were held for 24 hr. Flanges and dimensions were specified to conform with A.E.S.C. standards except that flange thicknesses were made to conform with Table I, mentioned above. The valves purchased were made of chrome-nickel steel with nitralloy trim.

Bolting

Material for studs and nuts was specified to conform with A.S.T.M. Specifications A-96-27, Class "C" material for

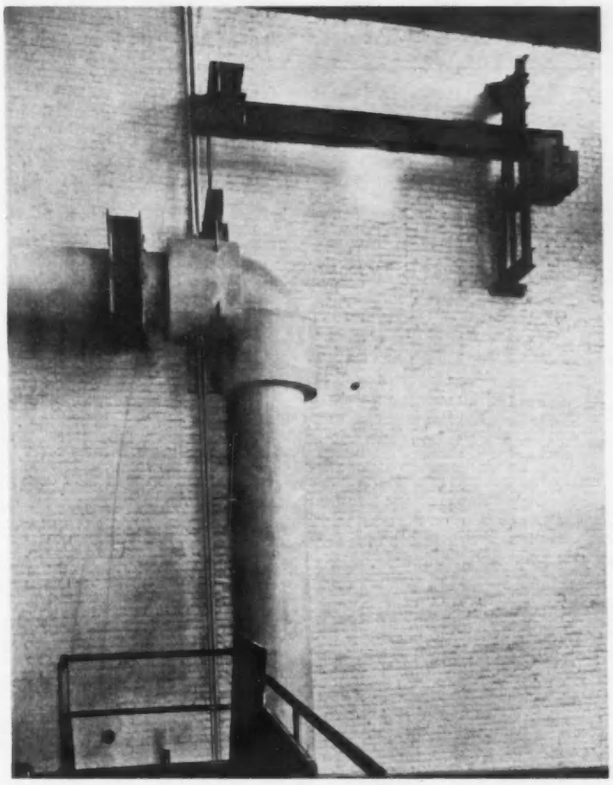


Fig. 12—Pipe support

studs. Dimensions of threads and nuts were made to conform with A.E.S.C. Tentative Standards of June, 1927. Studs made to these specifications and threaded full length with a continuous thread were found to give entire satisfaction.

Supports

All piping supports used on the major piping in the station were of the counterbalanced type, as shown in Fig. 12. This photograph shows a typical hanger used on the 20-in. reheat piping. The supporting beam of this particular hanger was fastened into the brick wall between the boiler and the turbine rooms. The beam, which carried the rod fastened to the pipe and the counterbalance weight, was connected to this supporting member and rotated on ball bearings, which assured the utmost freedom of motion. Ball-bearings were also used for the joint at the upper end of the supporting rod. The balance weights were made up in sections. At the extreme right of the picture, fixed in the brick wall, may be noted a limit stop which limited the movement of the pipe. The heaviest weight counterbalanced by this method was 44,000 lb. There were no anchors in the piping, sufficient flexibility being obtained by careful design so that reactions on the turbine and boiler outlets were well within the limits set by the manufacturers.

Pipe Covering

For all temperatures over 500 deg. F., combination covering, consisting of an inner layer of diatomaceous earth and an outer layer of 85 per cent magnesia was used. For ex-

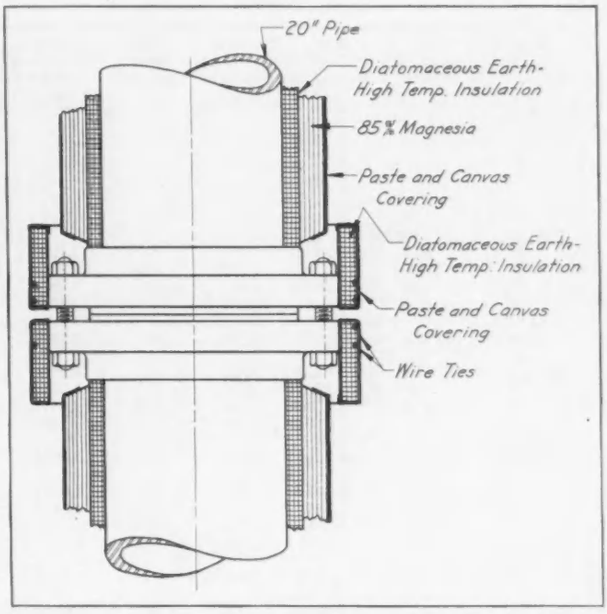


Fig. 13—Type of flange covering used on reheat piping, Station A, Pacific Gas and Electric Co.

ample, on the 12-in. high-pressure steam pipe, where the temperature was 750 deg. F., the thickness of the inner layer was 1½ in., and of the outer layer 2½ in. All flanges were covered on these lines. On the reheat steam lines, where flanged joints were subject to variations of temperature due to load changes, some trouble was experienced with leaky joints, due to the pipe joint cooling more rapidly than the studs. To overcome this, a special covering was designed to allow the studs to cool faster and the results with this type of flange covering have been found satisfactory. This method of covering is illustrated by Fig. 13.

*Over-all Economy Characteristics of 1,400-lb. Units at Station A**

Data are given in connection with the efficiencies obtained with the two 1,400-lb. units at Station "A" of the Pacific Gas and Electric Company, San Francisco, during the first eleven months of operation, including bogey curves showing the over-all economy characteristics at net outputs of from 5,000 to 64,000 kw., and curves of segregated power consumption of auxiliaries.

Results of First Eleven Months of Operation

ARTICLES have already been published in the technical press describing the principal equipment in this station and recently description of the more important operating features was published. (See "Operating Features of Station A" by C. E. Steinbeck, *Power*, November 17, 1931). It is intended that this report shall be supplementary to what has already been written.

The data for Table I have been taken directly from the operating records for the year 1931. The monthy and yearly averages and totals are given, together with the four best days of each month. If corrections are made for initial and reheat steam temperatures and vacuum, the values of B.t.u. per kw.-hr. given in the table have beeh found to check within plus or minus two per cent of the figures obtained from the bogey curves given in Fig. 2.

Factors Affecting Efficiency

The necessary experimental and test runs on turbines, boilers and auxiliary equipment have naturally taken precedence over any efforts towards obtaining most economical operating results, but it is felt that the efficiencies obtained

* Report of subcommittee on heat balance, design and plant betterment, prime movers committee, Engineering Section. J. M. Renfrew, chairman. M. R. Born, P. E. Chapman, V. F. Estcourt, T. M. Hotchkiss.

TABLE I

OPERATING FIGURES FOR STATION A

YEAR 1931

Pacific Gas and Electric Company
San Francisco

Date	Net output mw-hr	Gas fuel M cu.ft.	Turbine capacity factor	Net kw-hr per bbl	Net B.t.u. per kw-hr	Date	Net output mw-hr	Gas fuel M cu.ft.	Turbine capacity factor	Net kw-hr per bbl	Net B.t.u. per kw-hr
						Jul. 2	1835	18831	.626	514	12161
						3	2017	20771	.686	511	12245
						4	1606	16322	.548	517	12084
						7	1575	16234	.537	511	12235
						Monthly Totals	55,808	604,002	.669	487	12820
Feb.12	Unit No. 1 in service.					Aug.14	2532	26988	.905	492	12680
18	141	1910	.097	468	13390	15	1528	16061	.856	500	12506
19	281	3365	.197	484	12910	19	2200	23045	.917	500	12519
21	474	5273	.325	470	13300	31	2499	26514	.891	495	12626
22	252	2965	.173	480	13000	Monthly Totals	63,594	716,969	.801	466	13380
Monthly Totals	1,658	25,079	.234	401	15600						
Mar. 4	820	8112	.560	533	11750	Sep. 1	2353	25201	.837	489	12801
7	754	7389	.516	538	11610	2	2544	27055	.905	490	12762
8	860	8335	.586	538	11610	27	2434	25969	.864	493	12676
9	920	9196	.629	544	11490	28	2535	27497	.902	487	12799
Monthly Totals	15,969	169,016	.465	499	12550	Monthly Totals	65,685	716,391	.801	482	12970
Apr. 1	1018	10215	.696	522	11961	Oct. 4	1888	20081	.676	494	12660
7	1037	9940	.707	541	11607	12	2582	27602	.919	494	12666
8	1033	10343	.706	527	11867	13	2451	26178	.874	493	12687
10	885	8970	.605	520	12016	19	2614	27723	.929	494	12653
Monthly Totals	24,935	274,476	.762	478	13020	Monthly Totals	70,920	767,463	.825	485	12890
May 12	1239	12834	.846	501	12326	Nov.22	1429	15085	.512	494	12639
19	896	9191	.613	513	12189	23	1534	15724	.546	509	12296
21	1216	12229	.831	522	11969	25	1455	15084	.519	502	12496
30	943	9711	.645	510	12257	26	1494	15545	.536	499	12535
Monthly Totals	23,619	270,829	.644	458	13620	Monthly Totals	50,202	539,532	.599	486	12820
Jun. 4	1189	11892	.813	527	11852	Dec. 5	1583	16585	.564	496	12607
16	1237	12565	.845	517	12092	6	1487	15620	.516	497	12517
20	Unit No. 2 in service.					10	1447	15210	.533	492	12678
28	1650	15435	.563	534	11709	20	1487	15399	.529	506	12357
30	1810	17168	.617	530	11792	Monthly Totals	34,744	383,919	.405	471	13255
Monthly Totals	32,062	344,260	.645	490	12720						
						TOTALS FOR YEAR 1931					
							439,196	4,811,936	.664	479	13020

Note: (a) Table includes four best days of each month with monthly totals and averages.
(b) Turbine capacity factor equals gross output for 24 hours ÷ 61,000 x unit hours (H.P. and L.P. turbines considered as unit).
(c) During the year, boilers were fired almost entirely with gas fuel. In the monthly totals, the small amount of fuel oil burned has been converted into the equivalent number of cu.ft. of gas for convenience in tabulation.
(d) Net kw-hr per bbl is computed by converting the cu.ft. of gas used to equivalent barrels of oil on the basis of their relative calorific values.

during the first eleven months of operation are highly satisfactory, when all the factors are taken into consideration. During the first year of operation, there were naturally conditions which occurred in connection with some of the equipment which tended to reduce the operating efficiency. A number of boiler shut-downs were necessary, on account of leaks in the return bend joints on the economizers. At the

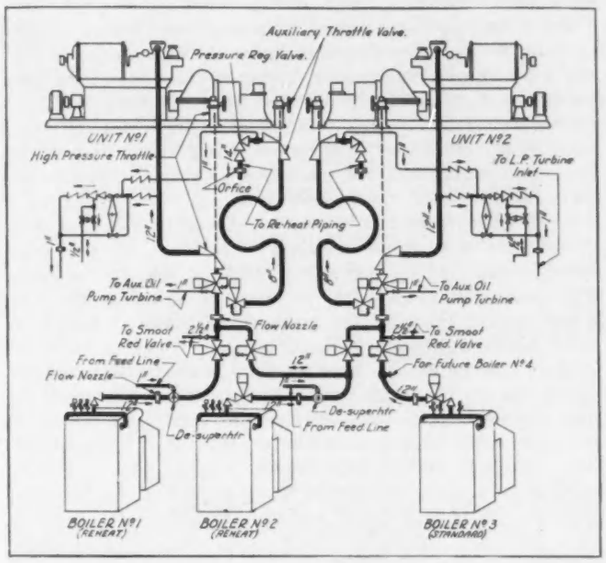


Fig. 1—Arrangement of 1,400-lb. piping between boilers and turbines, Units 1 and 2, Station A, Pacific Gas and Electric Co.

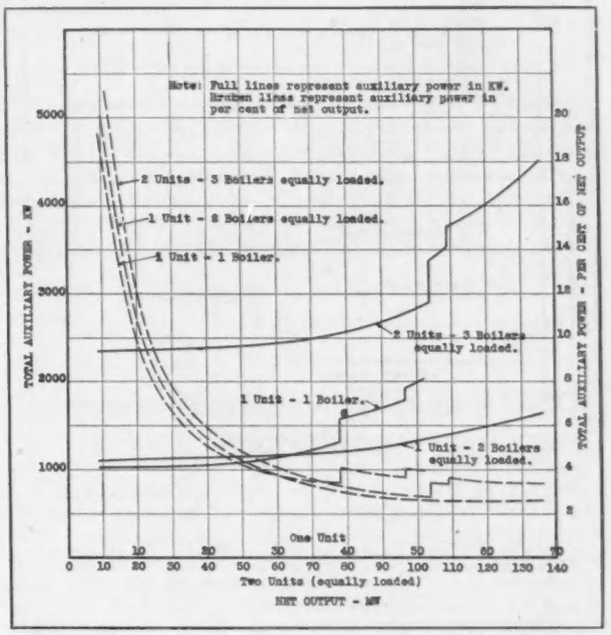

Note: Full lines represent auxiliary power in KW. Broken lines represent auxiliary power in per cent of net output.
2 Units - 3 Boilers equally loaded.
1 Unit - 2 Boilers equally loaded.
1 Unit - 1 Boiler.
2 Units - 3 Boilers equally loaded.
1 Unit - 1 Boiler.
1 Unit - 2 Boilers equally loaded.
TOTAL AUXILIARY POWER - KW
TOTAL AUXILIARY POWER - PER CENT OF NET OUTPUT
One Unit
Two Units (equally loaded)
NET OUTPUT - MW

Fig. 3—Total power consumption of auxiliaries, calculated from manufacturers' performance guarantees, Station A, Pacific Gas and Electric Co.

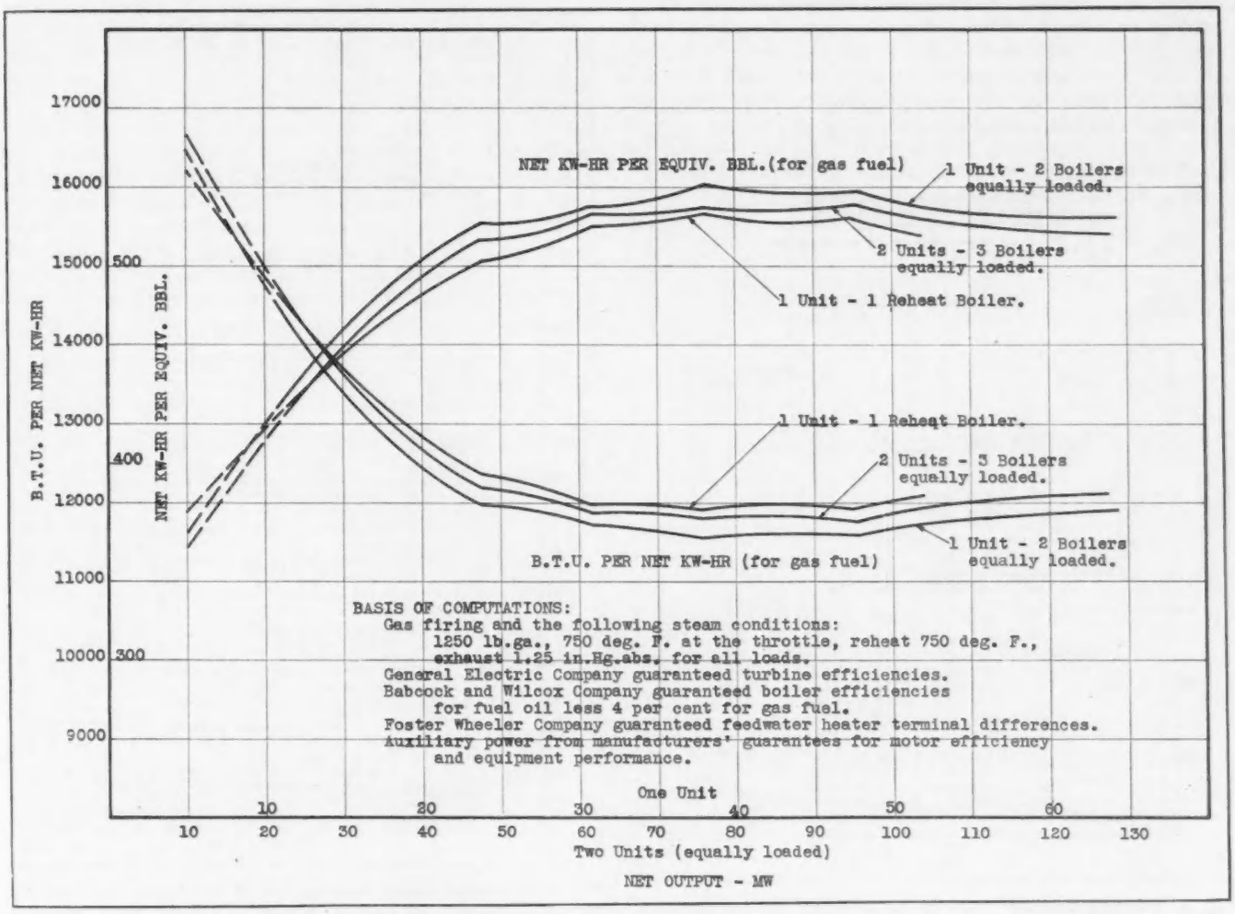

NET KW-HR PER EQUIV. BBL.(for gas fuel)
1 Unit - 2 Boilers equally loaded.
2 Units - 3 Boilers equally loaded.
1 Unit - 1 Reheat Boiler.
1 Unit - 1 Reheat Boiler.
2 Units - 3 Boilers equally loaded.
1 Unit - 2 Boilers equally loaded.
B.T.U. PER NET KW-HR (for gas fuel)
B.T.U. PER NET KW-HR
NET KW-HR PER EQUIV. BBL.
BASIS OF COMPUTATIONS:
Gas firing and the following steam conditions:
1250 lb.ga., 750 deg. F. at the throttle, reheat 750 deg. F., exhaust 1.25 in.Hg.abs. for all loads.
General Electric Company guaranteed turbine efficiencies.
Babcock and Wilcox Company guaranteed boiler efficiencies for fuel oil less 4 per cent for gas fuel.
Foster Wheeler Company guaranteed feedwater heater terminal differences.
Auxiliary power from manufacturers' guarantees for motor efficiency and equipment performance.
One Unit
Two Units (equally loaded)
NET OUTPUT - MW

Fig. 2—Over-all economy characteristics of 1,400-lb. units, calculated from turbine, boiler and auxiliary equipment guarantees, Units 1 and 2, Station A, Pacific Gas and Electric Co.

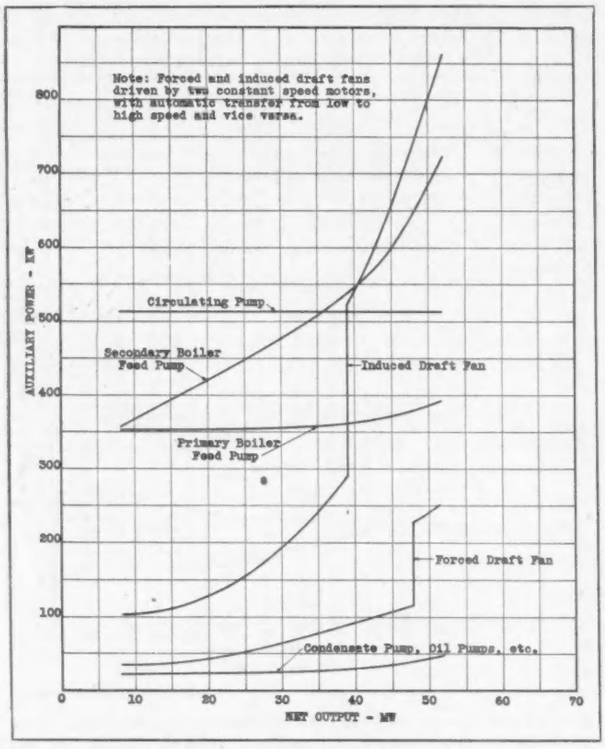

Note: Forced and induced draft fans driven by two constant speed motors, with automatic transfer from low to high speed and vice versa.
Circulating Pump
Secondary Boiler Feed Pump
Induced Draft Fan
Primary Boiler Feed Pump
Forced Draft Fan
Condensate Pump, Oil Pumps, etc.
AUXILIARY POWER - KW
NET OUTPUT - MW

Fig. 4—Segregated power consumption of auxiliaries for one unit and one boiler, calculated from manufacturers' performance guarantees, Station A, Pacific Gas and Electric Co.

time of writing this report, however, some improvements have just been completed in the method of making up the joints, which give promise of reducing the outages from this cause to a negligible figure. The steam reheaters were out of service part of the time for repairs to some small leaks that developed in the high-pressure elements. They have been operating very satisfactorily since that time. Trouble was also experienced with condenser leakage, which in turn resulted in excessive boiler blow-down losses and heavy loading of evaporators. These troubles have been overcome and it is now only on rare occasions that the boiler blow-down system is operated. The rapid accumulation of slime in the condenser tubes made it impossible to meet the condenser guarantees, but recently a chlorination system has been installed and the results thus far have indicated a marked improvement in vacuum. Some trouble has been experienced with high terminal differences on the high-pressure steel-tube feed-water heaters, due to corrosion. This has been caused by the low pH value of the feed water, rather than by the presence of oxygen. Steps are being taken to remedy this trouble.

The influence of this type of plant on the operating personnel has proved interesting. The operators appear to derive a greater individual satisfaction from their respective jobs than is the case in most plants operated at a lower pressure. This is undoubtedly due in part to the novelty of working in a plant embodying so many new and interesting features. It is gratifying, however, to find that a 1,400-lb. plant does not involve anything in its make-up that might produce the opposite effect.

Economy Characteristics at Full and Partial Loads

Due to conditions already mentioned, there is not sufficient data available at this time from which to prepare a com-

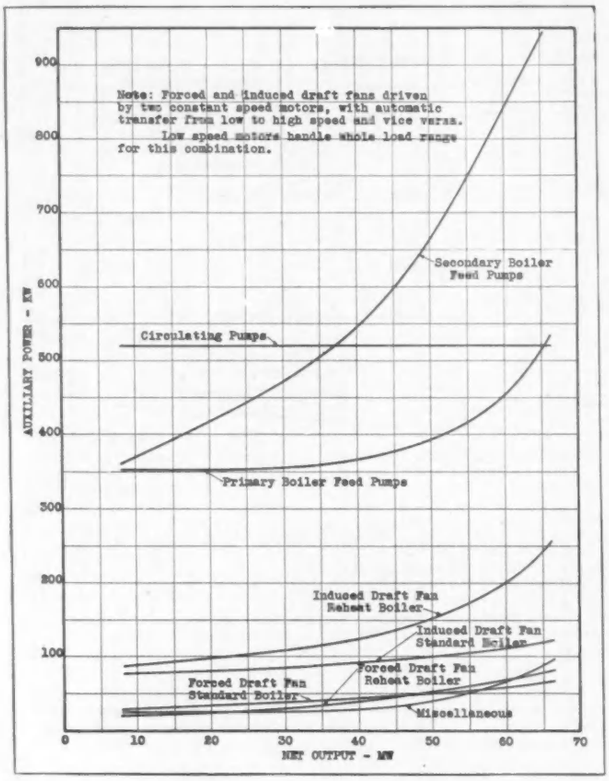

Note: Forced and induced draft fans driven by two constant speed motors, with automatic transfer from low to high speed and vice versa.
Low speed motors handle whole load range for this combination.
Secondary Boiler Feed Pumps
Circulating Pumps
Primary Boiler Feed Pumps
Induced Draft Fan Reheat Boiler
Induced Draft Fan Standard Boiler
Forced Draft Fan Reheat Boiler
Forced Draft Fan Standard Boiler
Miscellaneous
AUXILIARY POWER - KW
NET OUTPUT - MW

Fig. 5—Segregated power consumption of auxiliaries for one unit and two boilers, equally loaded, calculated from manufacturers' performance guarantees, Station A, Pacific Gas and Electric Co.

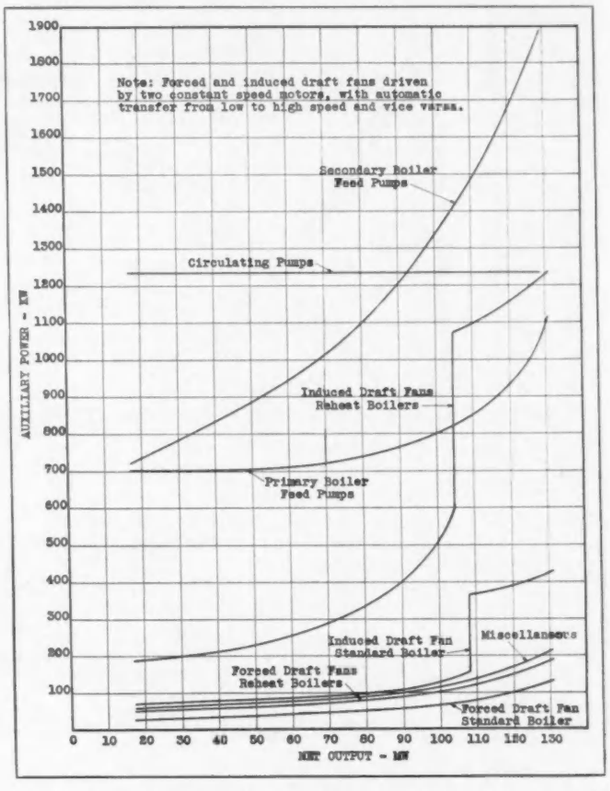

Note: Forced and induced draft fans driven by two constant speed motors, with automatic transfer from low to high speed and vice versa.
Secondary Boiler Feed Pumps
Circulating Pumps
Induced Draft Fans Reheat Boilers
Primary Boiler Feed Pumps
Induced Draft Fan Standard Boiler
Miscellaneous
Forced Draft Fans Reheat Boilers
Forced Draft Fan Standard Boiler
AUXILIARY POWER - KW
NET OUTPUT - MW

Fig. 6—Segregated power consumption of auxiliaries for two units and three boilers, all equally loaded, calculated from manufacturers' performance guarantees, Station A, Pacific Gas and Electric Co.

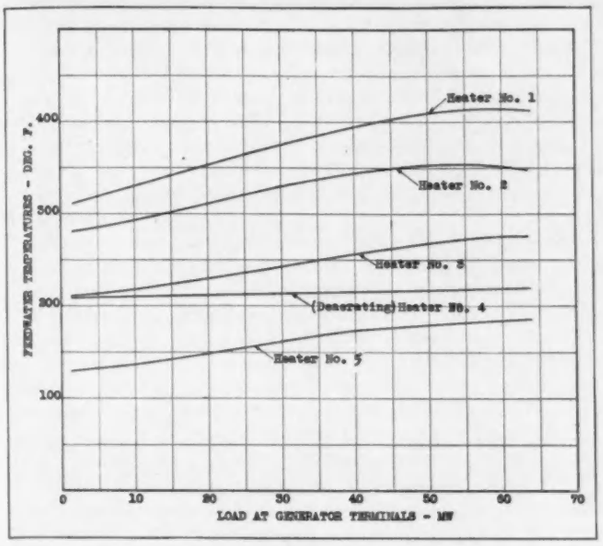


Fig. 7—Actual feed water temperatures leaving heaters at full and partial loads, Unit No. 1, Station A, Pacific Gas and Electric Co.

plete report on the operating efficiencies obtainable under the various boiler and turbine combinations possible in this plant. It was therefore thought desirable to present at this time only preliminary data which might serve as an introduction to a further report at some future time.

The diagram in Fig. 1 shows the general arrangement between boilers and turbines, and is included so that a proper understanding may be had of the data given in Fig. 2 for three different combinations of boilers and turbines. The curves are in the nature of bogeys, which furnish reference lines with which all actual operating results may be compared. These curves present a fairly good picture of what may be actually attained in practice, since all the conditions set down as a basis for the construction of the curves may be closely approached in operation, down to a load of about 15,000 kw. on each unit. At loads below this, the main and reheat steam temperatures will fall off appreciably and the boiler efficiencies also tend to fall below the manufacturer's guarantees, because it is difficult to maintain the specified combustion conditions in the furnace at light loads, due to excess air in the furnace. However, these conditions are not sufficiently well known at this time and it would be more appropriate to reserve a discussion of them for a future report.

Power Consumption of Auxiliaries

The curves given in Figs. 3 to 6 are bogeys of auxiliary power consumption, based on manufacturers' guarantees. Fig. 3 gives the total auxiliary power for each of the three combinations considered in Fig. 2. The segregated power consumption of the more important auxiliaries is given in Figs. 4, 5 and 6. The actual feed water temperatures obtained at different turbine loads are shown in Fig. 7.

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*Present Need For Efficient Plant Management**

The results of a study by one company of its labor distribution are given, together with comparisons made with other companies operating in the same territory. A comparison of salaries in three different plants is also given and the effect of the size of the generating units upon the number of operating employees is analyzed. Consideration is also given to the subject of health records of employees in relation to accident records and also to sickness in relation to age of employee.

EFFICIENT plant management has for its goal the reduction of production costs to the lowest possible value compatible with reliable and continuous service. At the present time, with every company trying to make its dollars do the most work, production costs are receiving close scrutiny by executives. Since fuel costs are determined largely by the load and type of equipment or station heat balance employed, labor costs remain the item which has received perhaps the smallest attention in the past. Due to the phenomenal load growth experienced by most companies in this

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* Report of subcommittee on plant management, prime movers committee, Engineering Section. F. G. Philo, chairman. Leslie A. Hicks, V. E. Johnson, F. R. Knight, H. A. Nobel, E. A. Quinn, J. M. Renfrew.

PLANT No 3

No	POSITION	Not Standby	Light Operation	Part Operation	Full Operation	Part Operation	Full Operation	Part Operation	Full Operation
1	WATCH ENGINEER	1	1	1	1	1	1	1	1
2	ASST. WATCH ENGINEER					1	1	1	1
3	HEAD FIREMAN	1	1	1	1	1	1	1	1
4	ASST. HEAD FIREMAN	1	1	1	1	1	2	2	2
5	FIREMAN	1	1	1	2	3	4	4	5
6	FUEL OIL TENDER			1	1	2	2	2	3
7	MAN TENDER		1	1	1	1	2	2	2
8	WATER TENDER								
9	BURNER CLEANER								
10	OIL KING (1 SHIFT PER DAY)	1	1	1	1	1	2	2	2
11	SR. TURBINE OPERATOR	1	1	1	1	1	1	1	1
12	JR. TURBINE OPERATOR			1	2	3	4	5	6
13	BOILER FEED PUMP TENDER		1	1	2	2	3	3	4
14	AUXILIARIES OPERATOR		1	2	2	2	3	3	4
15	OILER								
16	SCREEN TENDER (1 SHIFT DAY)	1	1	1	1	1	1	1	1
17	DIVISION OPERATOR								
18	SR. SWBD. OPERATOR	1	1	1	1	1	1	1	1
19	JR. SWBD. OPERATOR		1	1	1	1	2	2	2
20	WATCH ELECTRICIAN	1	1	1	1	1	1	1	1
21	SR. ELECTRICIAN	1	1	1	1	1	2	2	2
22	JR. ELECTRICIAN			1	1	1	2	2	2
23	TOTAL EMPLOYEES PER SHIFT-1 SHIFT DAY	10	14	18	21	25	35	36	41
24	TOTAL EMPLOYEES FOR 3 SHIFTS (INC. RELIEF)	30	44	58	66⅔	82⅔	113	118⅔	136

PLANT No 2

No	Cond. Standby	Not Standby	Light Operation	Part Operation	Full Operation
1	1	1	1	1	1
2					
3	1	1	1	1	1
4		1	1	1	1
5			1	2	3
6			1	1	1
7		1	1	1	1
8					
9					
10					
11		1	1	1	1
12				1	2
13			1	2	2
14			1	2	3
15					
16					
17	1	1	1	1	1
18	1	1	1	1	1
19			1	1	1
20	1	1	1	1	1
21	1	1	1	1	1
22				1	1
23	6	3	14	19	22
24	21	31⅔	49	66⅔	77

PLANT No 1

No	Not Standby	Light Operation	Part Operation	Full Operation	Part Operation	Full Operation
1		1	1	1	1	1
2						
3	1	1	1	1	1	1
4						
5		1	2	2	3	4
6						
7						
8	1	1	2	2	3	4
9					1	1
10						
11	1	1	1	1	1	1
12			1	2	3	4
13						
14						
15		1	2	2	3	3
16						
17						
18						
19						
20						
21						
22						
23	4	8	10	11	16	19
24	14	21	35	38⅔	58	66⅔

TABLE I
SHOWING NUMBER OF
EMPLOYEES REQUIRED FOR OPERATION
LONG BEACH STEAM STATION
SOUTHERN CALIFORNIA EDISON CO., LTD.
STEAM GENERATION DEPARTMENT

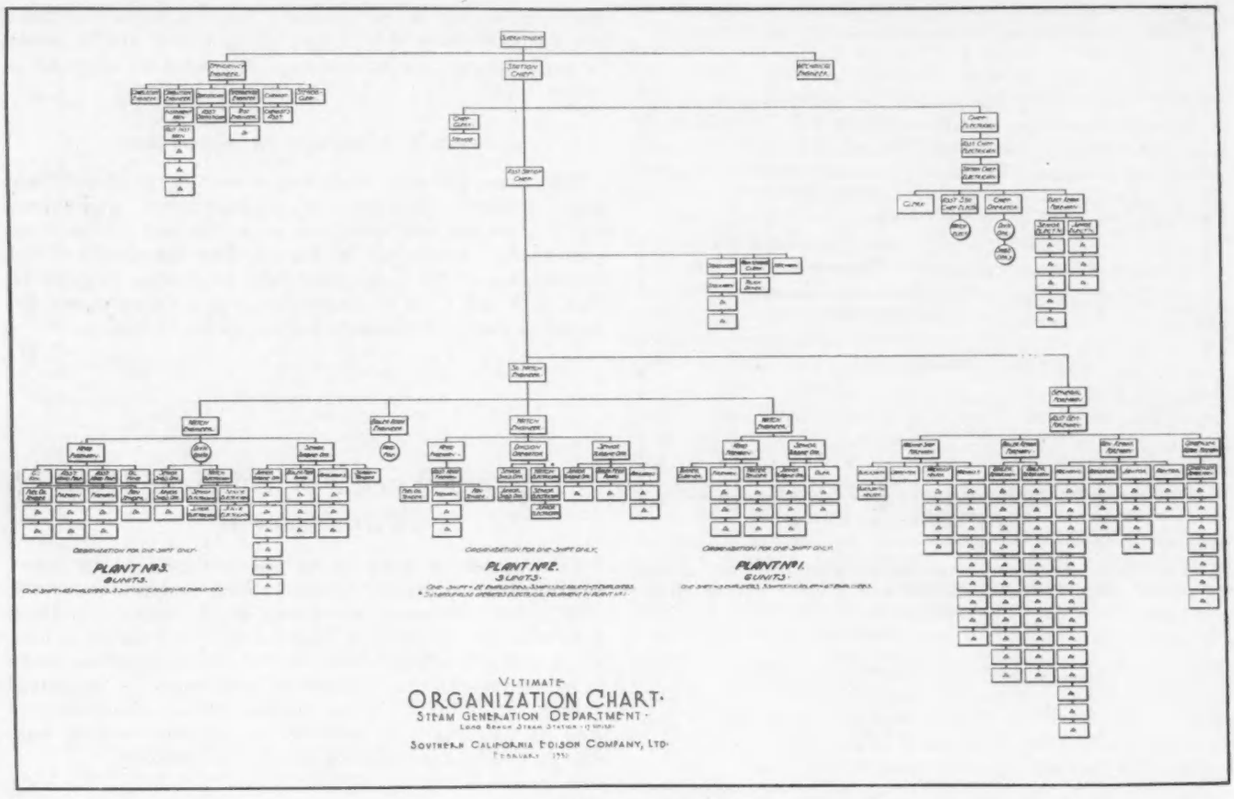

Fig. 1—Organization chart

territory during recent years, the engineering and design features of steam stations have been of immediate importance. Now that construction has been curtailed temporarily, reduction of operating expense occupies a larger portion of the thought of those in charge of plant management. The steam generation department of one company recently has made a study of its labor distribution and the results of this study together with comparisons made with other companies operating in the same territory are presented in this report.

Analysis of Labor Distribution for a Certain Plant

The major portion of the steam generating capacity of this company (designated in this report as company "A") consists of three plants located on the same property, with a combined generating capacity of 415,000 kw.

In making this study of labor distribution, an effort was made to design an organization as near the ideal as possible. The starting point was the preparation of a table showing the number of employees required for operation (Table I). Not only were the requirements for operation of the present equipment analysed and tabulated, but estimates were made of the operating personnel for future units of similar type. When completed, this table was discussed and the allotted number of men as shown by it was agreed to by all the department heads concerned. This agreement upon a fixed standard eliminates differences of opinon which might otherwise occur due to a supposed undersupply or oversupply of men for the positions indicated.

In addition to determining the number of future operators, estimates also were made of the increases in maintenance and superintendence forces necessary for the growth of the station. The relation of these three divisions is shown on the organization chart (Fig. 1).

Reporting directly to the superintendent are the efficiency engineer, the station chief and the mechanical engineer. The efficiency engineer is regarded as a consultant and advisor to the superintendent and as such he should be free to comment, and if necessary, criticize any department in the organization. The old feelings of jealousy and intrusion on the part of others, which formerly hampered the efficiency engineer in his work, have been eliminated as his work has been more and more appreciated. In the modern high-capacity station, the efficiency engineer's department has become an important and essential factor in the successful operation of the station.

The mechanical engineer handles the minor engineering problems which are continually arising in connection with that station's operation, maintenance and betterment.

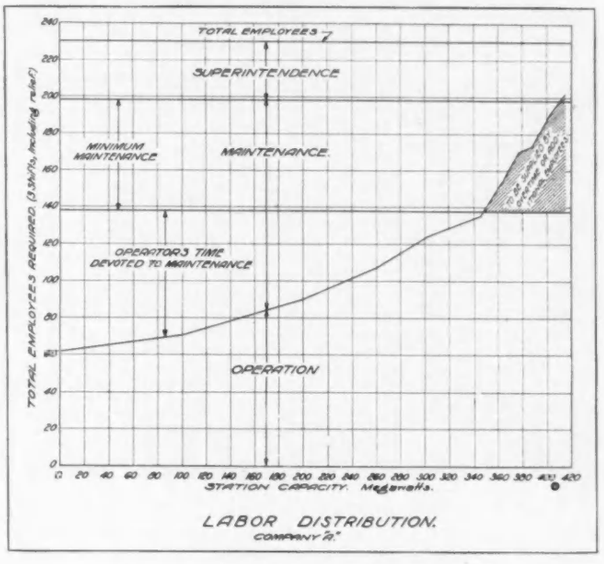

Fig. 2—Labor distribution, Company "A"

The remainder of the station's personnel, including the electrical department, the operating personnel and the maintenance force, is responsible to the station chief. The maintenance force has been organized under a general foreman, and an assistant foreman with subforemen each in charge of the machine shop, boiler repair, general repair and condenser repair crews. This arrangement has proven to be highly successful, as it allows the general foreman to shift men from one of his crews to the other according to the requirements of the work to be done.

A study of past records indicated that approximately sixty men would be required as a minimum maintenance force. This number is the minimum which can take care of all the maintenance work required to keep the station in good repair under normal operating conditions.

In addition to the minimum maintenance force, there are 32 men, who are grouped as "superintendence." This group consists of men whose work is of a strictly supervisory nature, as well as those who might be more properly classified as "base operation," yet who are a part of the department overhead. In other words, all the men not a part of the operation or maintenance groups are classified as "superintendence."

The relation between these groups is shown on the labor distribution chart (Fig. 2). Starting with the number of men required to maintain the two principal plants on "hot standby" operation, the number of operators required for operating the station for increasing capacities is plotted against station capacity. The increasing slope of this curve near the right end is due to the fact that the older, smaller units require practically the same number of men as the newer, larger units. If the number of operators is plotted against the number of units in service, a practically straight line results, so that the operating organization can be reduced to a formula.

The total number of employees is practically a constant, and from this number the superintendence group and the minimum maintenance force can be placed on the chart. It has been the policy of this company to provide only sufficient operators for the operation of the two newest plants, the oldest plant being maintained as a "cold standby" and operated only at infrequent intervals. The shaded area on the chart shows the operating region which normally must be supplied by overtime. However, if this plant were to be operated on a steady basis, the shaded area would indicate the number of new men required.

It is the practice of this company to use operators for maintenance work whenever the load drops below the point where the minimum maintenance line crosses the operation line, or 345 megawatts. At periods of light loads, the maintenance work is heavy, while at heavy loads the reverse is true. This arrangement works very well and avoids laying off operators that would otherwise be idle during light-load periods.

In the past no systematic method of checking the effectiveness of the utilization of the spare time of the operators had been followed. These studies have provided a basis for estimating the labor cost of operation of the individual generating units of the station and for determining the "labor efficiency" with which the operation is carried out.

From the labor distribution chart a similar chart may be prepared from a knowledge of the salaries paid for the different positions, which will indicate the charges accruing from operation. Then with this chart as a "bogey" or budget for operating labor cost, the "operating labor efficiency" can be ascertained by comparing the time actually charged to operation with the bogey.

Comparison of Salaries in Three Different Plants

Data on salaries paid by stations in this territory are presented on the salary comparison chart (Fig. 3). On this chart, percentages of the station chief's salary are shown for the principal positions, rather than actual salaries in dollars, due to the reticence of most companies in giving out salary figures. It should be remembered in a comparison of this sort, that although the station chiefs are all shown as being equal, actually their salaries and responsibilities vary according to the size of the organization of which they are the head. It is interesting to observe on this chart that the firemen occupy a comparatively low place on the salary scale, yet in most plants they are the ones who have control over the fuel burned and therefore over a large part of the money spent for the plant's operation. Their responsibility for operation is no less than that of some of

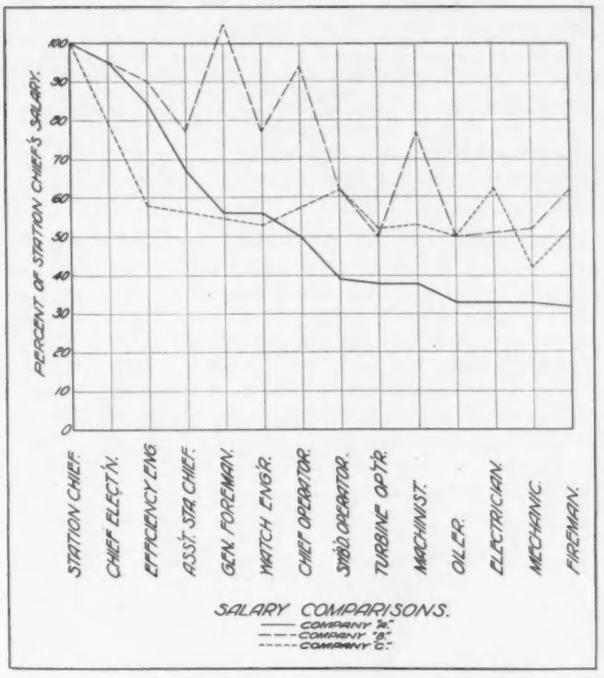

Fig. 3—Salary comparisons

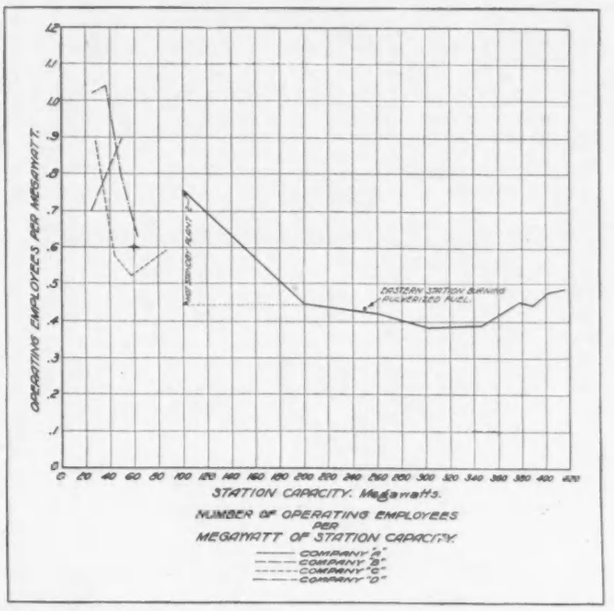

Fig. 4—Number of operating employees per megawatt of station capacity

the better-paid positions, so perhaps they deserve more consideration in the matter of salaries.

Effect of Size Units Upon Number of Operators

The number of operating employees per megawatt for several Pacific Coast plants is compared in Fig. 4. The reduction in the number of operating employees per megawatt, effected by large units and automatic control equipment, is shown by the curve representing company "A." If the number of men required for hot standby operation of Plant No. 2 is disregarded, the resulting curve (shown dotted) is consistently lower than those shown for the stations with smaller installed capacities. Most of the Pacific Coast stations use either oil or natural gas for fuel and it is interesting to compare the values shown on this chart with a corresponding figure from an eastern central station which uses pulverized coal for fuel. This station has a total capacity of 250 megawatts in five units, and requires 0.43 men per megawatt, which closely checks the Pacific Coast station of comparable capacity.

Analysis of Health Records of Employees

One company requires annual medical examination of each of the members of its steam-generation department. It has been felt in the past that insufficient attention was being paid to the employee's physical well-being and that poor health was a contributing factor in many accidents. The annual medical examinations by the company's physician were undertaken in an effort to improve the health of the men in the department, which should be reflected in decreased lost time due to accidents and sickness. The examinations were supplemented by meetings of the employees, at which talks on health improvement and accident prevention were given. Attendance at these meetings was entirely voluntary and the interest and enthusiasm shown were quite satisfactory.

It is difficult to show any tangible results from such a program of health improvement, possibly because it has not been in use for a sufficient length of time or because of the comparatively small number of cases. However, a careful analysis of the yearly examinations shows improvement in the general physical condition of the employees. Table II and Table III show the number of cases of sickness and accidents, with the time lost in man-hours since 1925. The high value of man-hours lost per case of sickness and accident in 1928 is due to a small epidemic of influenza which was prevalent at that time. The increase in this figure in 1931 is due to five cases of malignant illness, which made the number of man-hours lost time higher than ordinarily might be expected. It is these chronic cases which cause, in part, discrepancies in health curves and statistics. The larger percentage of lost time due to sickness indicates that more attention be paid to the matter of sickness, with the purpose of decreasing it to the lowest possible value.

In Fig. 5 are shown curves derived from the 1929 health examinations, showing the trend of the number of substandard men as a function of their age, as well as the age trend of the men in the department. These curves illustrate the desirability of keeping the age trend in the department at a comparatively youthful age, in order to avoid increasing the percentage of substandard men. These curves will vary according to the age of the organization to some extent. The newer stations might be expected to have the largest age group down in the younger brackets.

At the present time an effort is being made by this company to determine the trend of sickness and accidents as a function of the age of the employee, but these data are not available for publication at this time.

TABLE 2.
SICKNESS & ACCIDENT CASES.
COMPANY "A."

YEAR	NUMBER OF CASES		TOTAL	PERCENT OF TOTAL	
	SICKNESS	ACCIDENTS	CASES	SICKNESS	ACCIDENTS
1925	74	6	80	92.5	7.5
1926	54	10	64	84.5	15.5
1927	44	2	46	95.5	4.5
1928	52	3	55	94.5	5.5
1929	77	4	81	95.0	5.0
1930	73	9	82	89.0	11.0
1931	87	3	90	96.5	3.5

TABLE 3
SICKNESS & ACCIDENT
MAN-HOURS.
COMPANY "A."

YEAR	MAN-HOURS LOST		TOTAL MAN LOST	PERCENT OF TOTAL		MAN-HOURS PER CASE AVERAGE.		
	SICKNESS	ACCIDENTS		SICKNESS	ACCIDENTS	SICKNESS	ACCIDENTS	
1925	9152.	2560.	11,712.	78.1	21.9	124	426	147.
1926	3888.	2416.	6304.	61.6	38.4	72	242	98.
1927	3392.	268.	4260.	93.6	6.4	91	134	93.
1928	7552.	560.	8112.	93.1	6.9	145	187	147.
1929	8580.	864.	9444.	91.0	9.0	111	216	117.
1930	8340.	588.	8928.	93.4	6.6	114	65	109.
1931	10856.	136.	11052.	98.3	1.7	125	65	123.

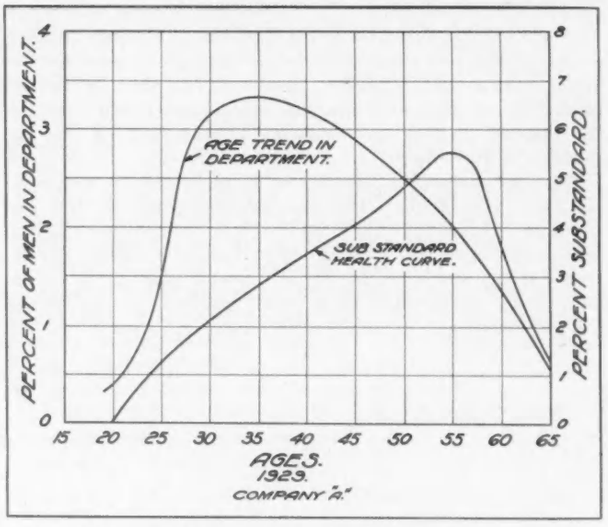

Fig. 5—Curves showing trend of number of substandard men as a function of their age

UNDERGROUND SYSTEMS COMMITTEE REPORTS[1]

*Corrosion of Lead, Its Causes and Remedies**

The subcommittee on corrosion has hitherto confined its investigations largely to the subject of electrolysis. This year it has devoted its attention to the less intensive and less understood, but more widespread, chemical attack.

THIS Association has heretofore confined its investigations of this subject largely to electrolysis. It is believed, therefore, that this phase of the corrosion problem is at least fairly well understood by electrical engineers, qualified by both education and practical experience, and it is presumed that all member companies are giving due consideration to the protection of their cable sheaths from electrolytic attack.

This conclusion is based upon a report of the underground systems committee, Engineering National Section, N.E.L.A., May, 1931 which states that:

> The report on cable operation during 1929 showed that about 15 per cent of failures in high-tension cables were caused by corrosion, 7 per cent being due to electrolysis and 8 per cent to chemical attack.

This statement suggested to the committee that it might be expedient for one year at least to attempt an investigation of the less intensive and the less understood, but more widely distributed, chemical attack. Whether or not this conclusion was well advised, remains to be seen. The research demands the technical ability of a trained chemist. It properly requires time and duplication of effort. It likewise calls for considerable outlay of money.

It might have been the course of wisdom and prudence, in the face of these difficulties, to have attempted a review and resumé of recent research papers that have been contributed to this subject by metallurgical and chemical engineers.

According to published papers, corrosion of lead sheaths of underground conductors may be due to one or more of the following causes:

1. Molecular stresses within the metal that may be occasioned by mechanical injuries incidental to the handling or installation, such as abrasions, compressions and stretchings.
2. Electrolytic action of current of dynamic and galvanic origins.
3. Chemical attack by contact with water or earths containing dissolved salts and gases.
4. Chemical attack due to its exposure to the air or the atmosphere of the manholes and ducts.

The committee is indebted to the valued ability and cooperation of Guy Corfield, chief chemist of the Los Angeles Gas & Electric Corp. and his staff, who have assisted in devising the experiments and are now carrying them out.

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[1] J. C. McClung, Los Angeles Gas and Electric Corporation, chairman. G. L. Hill, Pacific Gas and Electric Company, vice-chairman.
Columbia Steel Company: H. N. Pratt.
Copperweld Steel Company: C. E. Ingalls.
General Cable Corporation: J. E. Crilly, O. R. Grant, J. C. Pyle.
General Electric Company: D. I. Anzini, G. P. Mackenzie.
Kerite Insulated Cable Company: J. P. Robinson.
Okonite Cable Company: I. W. Borda, T. T. Kennedy.
Los Angeles Gas and Electric Corporation: P. F. Melnick, E. R. Northmore, Z. T. Pettit, G. A. Riley, B. A. Williamson.
Pacific Gas and Electric Company: G. Brand, R. R. Cowles, W. K. Cullen, G. H. Hagar, G. L. Hill, R. P. Lutzi, H. C. Moyer, F. Stiver, P. Suransky.
San Diego Consolidated Gas & Electric Company: K. B. Ayres.
San Joaquin Light & Power Corporation: H. H. Minor.
Southern California Edison Company Ltd.: C. E. Biggs, W. C. Curl, J. C. Gaylord, N. B. Hinson, J. F. Hodges, E. F. Randolph, E. R. Stauffacher.
The Southern Sierras Power Company: E. Y. Porter, A. C. Putman.
Westinghouse Electric & Manufacturing Company: C. A. Andrews, P. B. Garrett, C. C. Potts.

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* Progress report of subcommittee on lead corrosion, underground systems committee, Engineering Section. B. A. Williamson, chairman. I. W. Borda, Geo. Brand, O. R. Grant, H. M. Pratt, E. F. Randolph, Fred Stiver.

The purpose of these experiments was to determine more accurately, if possible, the natures and the intensities of the various contributory factors of corrosion.

An effort was made to outline these laboratory tests in such a way as to conform, as nearly as may be possible, to

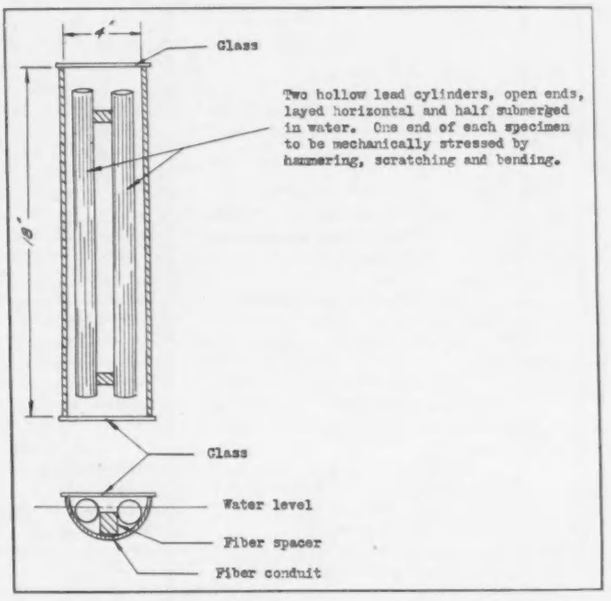

4"
Glass
Two hollow lead cylinders, open ends, layed horizontal and half submerged in water. One end of each specimen to be mechanically stressed by hammering, scratching and bending.
18"
Glass
Water level
Fiber spacer
Fiber conduit

Fig. 1—Construction of cells, test series No. 1

practical field conditions. One factor was varied in each test, so that it may be possible to discover just what is the cause of each type of corrosion.

Test Series No. 1

Cells were constructed as shown in Fig. 1. An 18-in. piece of fiber conduit was cut in half longitudinally. The two test pieces are thin-walled lead pipe, each being bent, scratched and hammered at one end. In this series, the results of direct and alternating currents, molecular stresses and different kinds of electrolytes are to be separately studied.

In the following tabulations a more specific description of each test, its principal objective and general observations taken for a few weeks are given. Since it was not thought advisable to remove the electrodes from time to time for examination of their surfaces that contact the electrolytes,

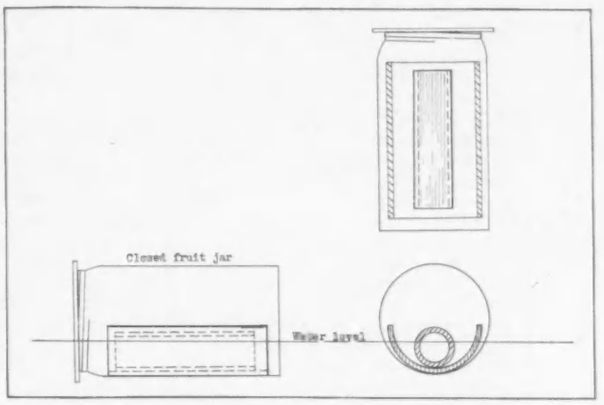


Fig. 2—Construction of cells, test series No. 3

Test No.	Description of Test		
1A	Fiber duct cell - 2 lead pipes half immersed in manhole water. 1.5 volts d.c. potential between pipes. Objective: To study action of direct current in producing electrolysis.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	Pos. White deposit along water-air line and on end under water. Neg. Orange deposit along water-air line. Pos. Yellow deposit with white edges on water-air line and under water. Neg. Rust color deposit (also little yellow) along water-air line. Few spots yellow under water. Both pipes have few white spots over air surface. Pos. Same except some rust color deposit under water surface. Neg. Same as previous date. Both pipes - white spots disappeared from air surface. Same as previous date. Same as previous date except heavier deposits. Yellow-white deposit from Pos. pipe collecting in bottom of cell.
1B	Fiber duct cell - 2 lead pipes half immersed in manhole water. 6 volts a.c. potential between pipes. Objective: To study the effect of alternating current in producing corrosion.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	White deposits scattered over air surface in small spots. Same as previous date plus few orange spots on water-air interface. Same as previous date. Same as previous date. Same as previous date.
1C	Fiber duct cell - 2 lead pipes half immersed in manhole water. No potential or connection. Objective: To study chemical corrosion of stressed and unstressed lead in contact with air and manhole water.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	White deposit in scratches. Heavy white deposit and some rust colored deposit over air surface. Some rust colored deposit under water. White deposit much heavier in scratches. Same except more deposit on right hand pipe. Same except right hand pipe air surface almost covered with white, yellow and orange deposits. Same as previous date.
1D	Fiber duct cell - 2 lead pipes half immersed in tap water. No potential or connection. Objective. Same as Test 1C except tap water is used.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	Small white deposit in scratches and scattered over air surface. White deposits heavy in scratches with spots of yellow, rust, and red colored on air surface. White deposit heavier. White deposit still heavier. Same as previous date.
2A	Fiber duct cell - 1 lead pipe and 1 copper pipe, externally connected. Half immersed in manhole water. Objective: To study the effect of bare copper neutral conductors in causing galvanic corrosion to lead sheaths.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	Lead pipe has small white deposit scattered over air surface. Copper unaffected. Lead pipe has medium white deposit on air surface. Rust colored deposit on air-water line. Copper unaffected. Same except small yellow deposit on air-water line of lead. Same except rust colored deposit over end of lead. Same except heavier deposit on lead.
2B	Fiber duct cell - 1 lead pipe and 1 iron pipe, externally connected. Half immersed in manhole water. Objective: To study the cathodic protection afforded by underground iron pipes to which the neutral conductors and lead sheaths are connected.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	Lead pipe has small white deposit scattered over air surface. Thicker in scratches. Iron pipe slightly rusted. No change in lead pipe. Iron pipe badly rusted. Same as previous date. Same as previous date, except heavier deposit on lead pipe. No change in lead pipe. Iron pipe rusted heavily. Rust on bottom of cell.
2C	Fiber duct cell - 1 lead pipe and 1 zinc pipe, externally connected. Half immersed in manhole water. Objective: To study the cathodic protection that maybe afforded to lead sheaths that are made negative to the earth by electric drainage ties to electric railway substation negative buses.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	Lead pipe has small white deposit over air surface. Zinc unaffected. No change on lead except yellow-orange deposit on water-air line. Zinc pipe has heavy white to yellow deposit along water-air line and also under water. Deposit on zinc pipe is heavier. No change. Deposit on zinc pipe is still heavier - covering bottom of duct.
2D	Fiber duct cell. Lead pipe with heavy copper wire soldered on. Half immersed in manhole water. Objective: To study the effect of galvanic electrolysis caused by bare copper tie wires in water filled manholes.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	Lead pipe has small white deposit scattered over air surface. Copper wire unaffected. Slightly heavier deposit on lead pipe. No change. White deposit on lead pipe getting heavier. No change.

Test No.	Description of Test		
3A	Glass jar - lead pipe - fiber duct - tap water.	1-8-32	No change.
		1-14-32	No change.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	No change.
3B	Glass jar - lead pipe - Soapstone duct - tap water.	1-8-32	No change.
		1-14-32	One rust color spot on air surface.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	Some blue and green color over air surface.
3C	Glass jar - lead pipe - cement duct - tap water.	1-8-32	No change.
		1-14-32	No change.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	Three rust color spots on water-air line.
4A	Glass jar - lead pipe - fiber duct - manhole water.	1-8-32	No change.
		1-14-32	One small red spot air surface.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	No change.
4B	Glass jar - lead pipe - fiber duct - manhole water saturated with carbon dioxide gas.	1-8-32	No change.
		1-14-32	Two small rust color spots on air surface.
		1-19-32	No change except oily appearance on water-air line.
		1-26-32	Heavy white-yellow deposit on water-air line.
		2-24-32	No change.
4C	Glass jar - lead pipe - fiber duct - tap water saturated with dioxide gas.	1-8-32	No change.
		1-14-32	One yellow spot under water.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	No change.
4D	Glass jar - lead pipe - fiber duct - tap water saturated with carbon dioxide gas plus 1% acetic acid.	1-8-32	White precipitate in water.
		1-14-32	White deposit over air surface.
		1-19-32	Deposit slightly heavier.
		1-26-32	No change.
		2-24-32	Deposit changing to yellow-white.
4E	Glass jar - lead pipe - fiber duct - tap water saturated with sodium bicarbonate.	1-8-32	No change.
		1-14-32	No change.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	No change.
4F	Glass jar - lead pipe - fiber duct - tap water saturated with 1% sodium chloride.	1-8-32	No change.
		1-14-32	Three small orange spots on air surface.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	White deposit on air surface.
4G	Glass jar - lead pipe - fiber duct - tap water saturated with 1% sodium sulphate.	1-8-32	No change.
		1-14-32	One rust colored spot on air surface and one on water-air line.
		1-19-32	No change.
		1-26-32	No change.
		2-24-32	Several orange-rust colored spots on air surface and air-water line.
4H	Glass jar - lead pipe - fiber duct - tap water saturated with 1% ammonium hydroxide.	1-8-32	No change.
		1-14-32	No change.
		1-19-32	Oily appearance on air surface.
		1-26-32	No change.
		2-24-32	No change.
	Note: All No. 4 series have lead pipe half immersed in water and a small weighed piece of lead wire under same exposure.		

Test No.	Description of Test		
5A	Chemical flask filled with tap water. Lead and copper wires suspended in water, externally connected.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	No change. No change. No change. No change. Fluffy yellow deposit on bottom of flask.
5B	Chemical flask filled with tap water. Lead and iron wires suspended in water, externally connected.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	Medium rust in water from iron wire. Some deposited on lead wire. Rust deposit becoming more pronounced. No change. No change. No change.
5C	Chemical flask filled with tap water. Lead and zinc wires suspended in water, externally connected.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	No change. Small amount of white deposit on bottom of flask. No change. No change. No change.
5D	Chemical flask filled with tap water. Lead wire suspended in water.	1-8-32 1-14-32 1-19-32 1-26-32 2-24-32	No change. No change. No change. No change. Fluffy yellow deposit on bottom of flask.
	Note: All of these tests were started 1-5-32.		

or for reweighing for the purpose of determination of the losses due to corrosion, any general observations that have been made to date must be considered to be of a superficial nature.

Test Series No. 2

Cells similar to those used in Series No. 1 were used, except that only one electrode was lead. The electrodes were half covered with a composite manhole water. The general object was to measure the polarities and the intensities of galvanic currents in terms of milliamp. per sq. ft. of sheath surface and to determine from loss of weight and condition of electrodes the intensities of galvanic corrosion and the value of cathodic protection.

Test Series No. 3

Cells were constructed by putting pieces of lead pipe and conduit in wide-mouthed quart glass jars. Tap water was added to half cover the lead pipe when the cell lies on its side. The construction of these cells is shown in Fig. 2. These tests were devised to afford means of observing the corrosive qualities of the several conduit materials.

Test Series No. 4

Cells were constructed similar to those used in Series No. 3, except that fiber conduit was used throughout. These tests were intended for the purpose of studying the chemical attacks of various acids, salts, etc.

Test Series No. 5

Small pieces of fine lead wire, after being weighed, were connected externally to wires of other metals and immersed in tap water. The object of these tests was the same as in Series No. 1. It was thought that the corrosion losses could be calculated more accurately in per cents for fine wire than in heavy electrodes.

Original Expectations and General Observations

It was expected that lead stressed by mechanical means would show increased corrosion. At the present time this has been borne out by observations made upon surfaces exposed to the air. It was expected, of course, that direct current would rapidly corrode the lead, and that the lead would become charged with voltage somewhat like storage battery plates. One electrode is badly decomposed. There is 1.2 volts between electrodes immediately after the battery is disconnected. It was believed that the practice of using bare copper neutrals and bare copper wire for cross-bonding in water-filled manholes was conducive to corrosion. The experiment would seem to warrant this conclusion. At the end of two months, the galvanic current between two electrodes (one copper and one lead), each 18-in. in length and 1-in. in diameter and half submerged in electrolytic water, is 0.7 milliamp. The Bureau of Standards states that 3 milliamp. or more, is heavy electrolysis for iron pipes. Considering that one amp.-yr. quantity of electricity will decompose 74 lb. of lead, or that it is 3½ times more susceptible than is iron, and that the walls of the lead sheaths are much thinner than are those of iron pipes, it is believed that 0.7 milliamp. of galvanic current, which is distributed over a relatively small area, will prove quite destructive. It was believed at the outset of the test that the practice of cross-bonding lead sheaths to underground pipes would afford a certain small degree of cathodic protection to the cable sheaths. Tests made at the end of two months show a gal-

vanic potential between iron and lead of 0.04 volts and 0.25 milliamp., which are in favor of the lead. It was also somewhat confidently believed that when cables are electrically drained to potentials below that of the earth, say to the degree of zinc to lead potentials, that electrolysis under these conditions might prove to be a deterrent to chemical corrosion. Tests made at the end of two months show galvanic potentials of 0.13 volts and 0.75 milliamp. in favor of the lead. Visual inspections and determinations of losses of metal by corrosion will not be possible until the conclusion of the test.

Attention is called to two excellent papers, "Corrosion of Lead, Its Causes and Remedies" by J. P. Millwood, chief chemist, and R. J. Wiseman, chief engineer of the Okonite Company, and "Corrosion of Lead as Affected by Mechanical Stress" by G. D'Eustachio of the General Cable Corp.

The following is an analysis of "the composite manhole water" being used to conduct the lead cable corrosion test.

Bicarbonate, HCO_3	41.9
Chloride, Cl	11.3
Sulphate, SO_4	4.7
Calcium, Ca	0.6
Magnesium, Mg	0.5
Sodium, Na	22.9
Silica, SiO_2	0.1
Iron (as Fe_2O_3)	0.3
Total solids	82.3
Evaporation residue (@ 270 deg. F.)	68.4
Ignition residue (at white heat)	61.1
Ignition loss	7.3

(All figures in grains per U. S. gallon.)

*Development of Low-Cost Underground Distributing System**

A number of low-cost underground systems have been installed in residence districts and in other locations where an overhead system is objectionable to property owners, indicating that the public utilities are making some effort to promote the good will of their consumers. While these installations may be regarded as experimental at this time, if found fairly reliable in service, it may be expected that improvements will be developed which may lead to a more extended application of such systems.

Areas Applicable

THE development of a low-cost underground system has long been favored by many electric distribution companies in areas where an overhead system is objectionable due to public opinion, or in residential areas of a high-class nature in which the property owners desire the distinct advantage of being able to beautify their property with trees and shrubs of an ornamental nature.

A good many subdividers of property have realized that the absence of pole lines adds an attraction to the sale of their property and have consequently paid for the initial installation of a standard underground system. This cost, of course, has been added to the price of the lots, a method which has proven a very satifactory initial solution. In some cases this underground system has been deeded to the utility for the price of an equivalent overhead system. From this time on, these areas are committed to underground construction. Any extensions due to growth, or requirements of additional feeders, rearrangement of transformers or secondaries, must be underground and of a much more expensive construction than an overhead system.

Early Efforts to Develop a Low-Cost Underground System

In some of the beautiful areas in and near Santa Barbara, some very inexpensive laterals of underground construction were installed about 1917. These areas were widely scattered and consisted mainly of branches from overhead feeder lines serving a limited number of customers on each branch. Since the original installation additional consumers have been added. Fig. 1 shows the extent of some of these areas. As far as possible, the pole lines were built in an inconspicuous location and the underground system extended along areas where poles would have been objectionable or impossible due to trees and gardens.

Description of Primary and Secondary Runs

In general the primary laterals were drawn in 1½-in. pipe, installed along the rear property lines at a depth of 12 to 18 in. Some of these conduit runs exceed 1,000 ft. between feeder point and first transformer installation.

The Primary Conductor Consisting of Cambric-Insulated Wire

Metal-pipe tees of twice the internal diameter of the pipe were inserted at convenient places in the system for pulling the conductor. The wire was pulled out through the opening in the tee for splicing. After splicing, a piece of fibre duct was placed over the conductors and a short piece of pipe just sufficient to reach the surface of the ground was placed over the fibre duct and screwed into the tee. The pipe was then capped. Fig. 2 shows one of these pulling points with pipe and cap.

Fig. 2—Pulling point with pipe and cap

The secondary runs were of a double-braid rubber-covered wire in metal conduit. Convenient pull-boxes and splicing chambers for service taps were provided. These junction boxes were of sewer tile pipe, 24 in. in length and 14 in. in diameter, with removable concrete lid. From these junction boxes, service laterals were run to the property of consumers to be served. Fig. 3 shows the method of installation of these secondary pull-boxes and the manner in which the secondaries entered the junction chamber, also service lateral taps.

Vaults for Transformer Installations

These vaults were made of concrete sewer tile in three sizes, installation depending upon the size of transformer

* Report of subcommittee on development of a low-cost underground distributing system, underground systems committee, Engineering Section. J. F. Hodges, chairman. C. R. Benson, J. E. Crilly, W. C. Curl, G. H. Hagar, P. F. Melnick, H. H. Minor, C. C. Potts, E. Y. Porter.

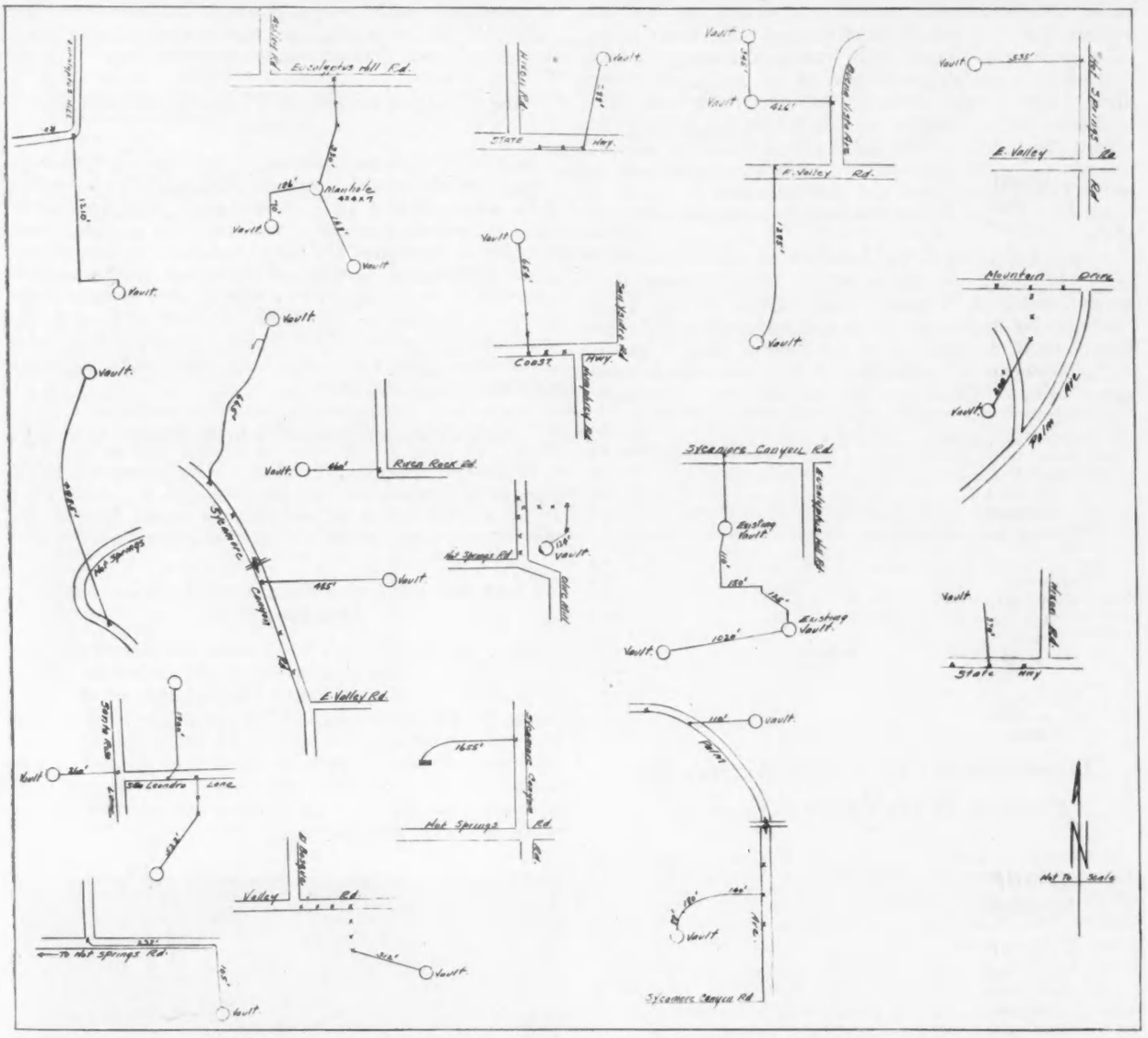


Fig. 1—Areas near Santa Barbara where inexpensive laterals were installed about 1917

required, as shown in Fig. 4. Inasmuch as these vaults were installed about two thirds of their length above ground, locations were selected so as to be as little objectionable as possible, as shown in Fig. 5, where the vault is almost entirely concealed by shubbery. Fig. 6 shows another similar vault at the rear of a house.

Fig. 7 shows one of these transformer vaults with the cover removed and the transformer installed. The small square pull-box at the left of the vault is part of the telephone installation.

Fig. 8 shows a conduit run at the time of the original installation. In the foreground is a secondary pull-box and in the background a transformer vault.

Operating Record

The majority of these systems have been in operation over a period of fifteen years. The failures that have occurred have been mostly insulation failures, and the majority of them have been on the primary system. There have been a total of about 26 failures recorded. It is doubtful if this number of failures would have been any less on an overhead system, considering the areas traversed. Recently some modifications were made in the primary conductor in this system, when the operating voltage was changed from 2,300 to 4,000. These changes consisted of the replacement of the cambric-insulated wire with lead-covered paper-insulated wire of 5,000-volt insulation.

Development of Buried-Type Non-Metallic, Non-Lead Sheath Cable

Except for a few short laterals of metal-armored cable buried directly in the ground, no further attempts were made to develop a low-cost underground system. In the meantime, the cable companies had been endeavoring to develop a non-metallic, non-lead sheath cable that could be buried directly underground. About 1928 or 1929 the cable companies announced a cable that seemed to have some promise of satisfaction for low-voltage secondary, street lighting and circuits up to 5,000 volts. The insulation consisted of rubber, paper tape and asbestos calk, with a final sheath of impregnated jute. This cable had a protective sheath, tough enough to withstand fairly rough handling and a reasonable

resistance to cutting and abrasion from tools. It was moisture-proof and impervious to earth acids and alkalis.

Necessity for Rerouting Overhead Line Suggests Low-Cost Underground

One of the operating companies found it necessary to reroute some of its existing overhead distribution equipment

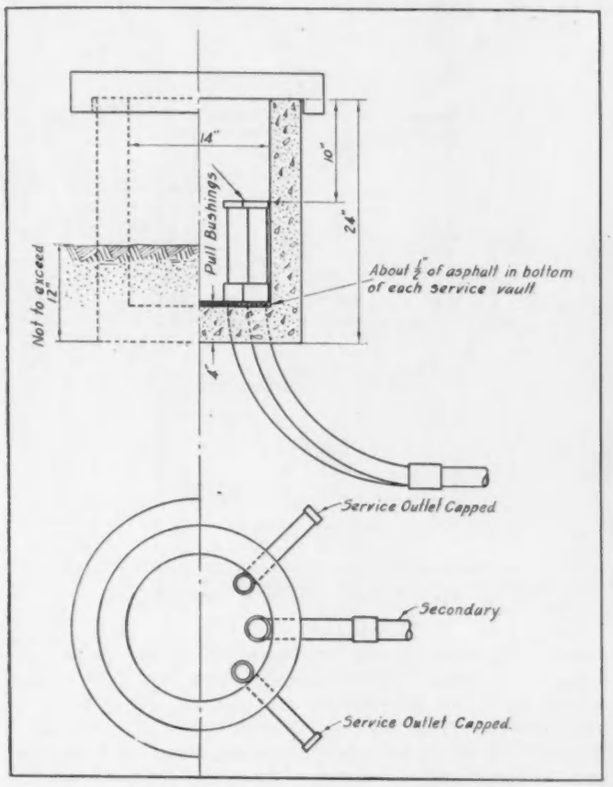


Fig. 3—Method of installing secondary pull-boxes

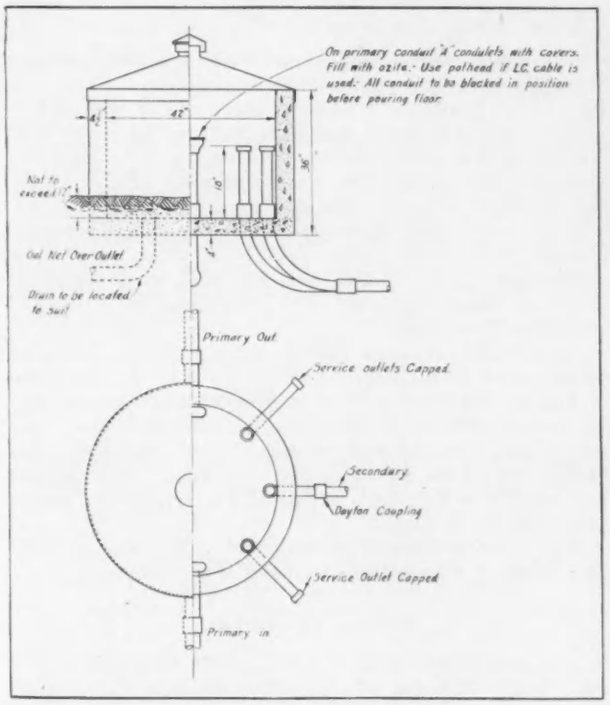

On primary conduit 4 condulets with covers. Fill with ozite. Use pothead if LC cable is used. All conduit to be blocked in position before pouring floor
42"
36"
10"
Not to exceed 12"
4"
Out Not Over Outlet
Drain to be located to suit
Primary Out
Service outlets Capped
Secondary
Dayton Coupling
Service Outlet Capped
Primary In

Fig. 4—Vaults are made of concrete sewer tile in three sizes depending upon size of transformer required

along a highway that was undergoing widening and improvement. The replacement of the poles along the roadway, which was on the slope of a hill, through a fine residential section, was strenuously opposed by the residents. The roadway on the upper slope of the hill extended to an almost perpendicular bank, with no room for the pole. The downward slope was rather steep and would have required poles of considerable height properly to clear the roadway. In order to set any poles above the roadway, rights of way would have been necessary. The residents readily agreed to grant rights of way along the rear property lines in consideration of the facilities being placed underground.

The cost of replacing the overhead system, plus the objection of the residents and the final impossibility of obtaining rights of way, led to a consideration of the installation of

Fig. 5—Vault almost completely concealed by shrubbery

Fig. 6—Similar vault at rear of house

Fig. 7—Transformer vault with cover removed

some of the before-mentioned non-metallic, non-lead sheath cable.

Description of the System

Fig. 9 shows the extent of the underground system as finally installed. A feed-in point from an overhead source was established at (A), as shown on the print, from whence a cable was laid to a pull-box at base of pole (B). From this point the system divides in two laterals. One is extended up pole (B), thence easterly over an existing overhead line to pole (C). From this pole, a cable runs into a standard conduit system of concrete-incased fiber ducts with manholes and vaults, as shown along Crown Ave. The other lateral from the pull-box at (B) extends along property lines crossing Oriole Ave. and Blythe Rd. to a pole at (D), thence overhead on an existing overhead line to an existing pole (E). From this point (E), a lead-covered cable in 2-in. conduit extends into the club house.

Fig. 8—Conduit run at time of installation

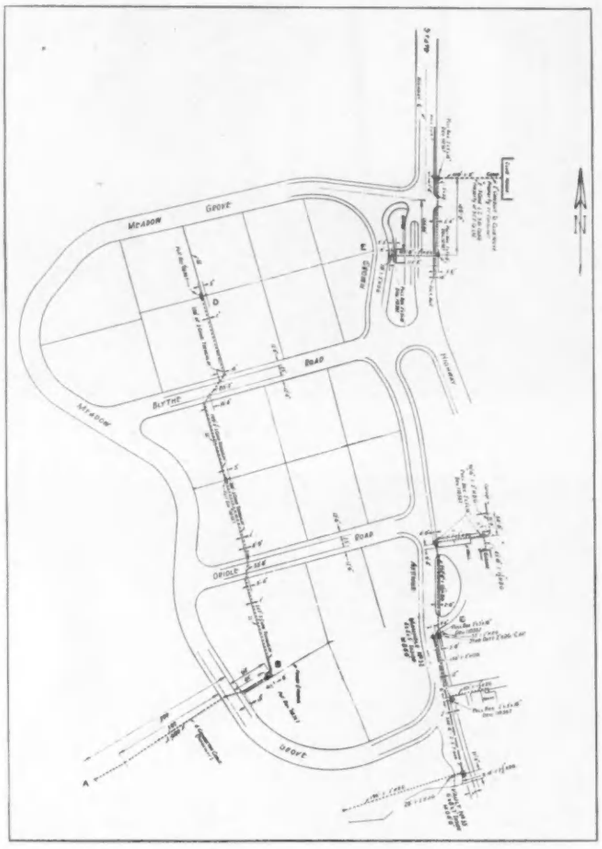


Fig. 9—Extent of underground system as fully installed

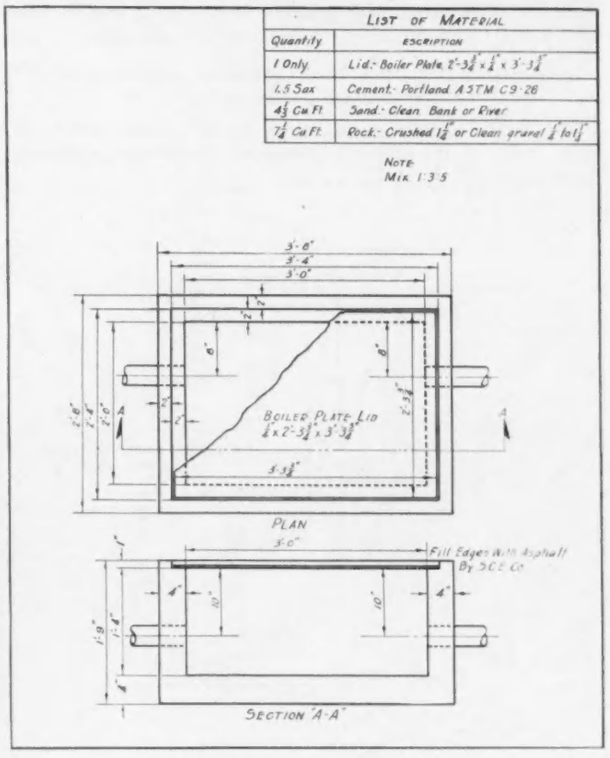


Fig. 10—Construction of pull-box

Use of Buried Non-Metallic, Non-Lead Sheath Cable

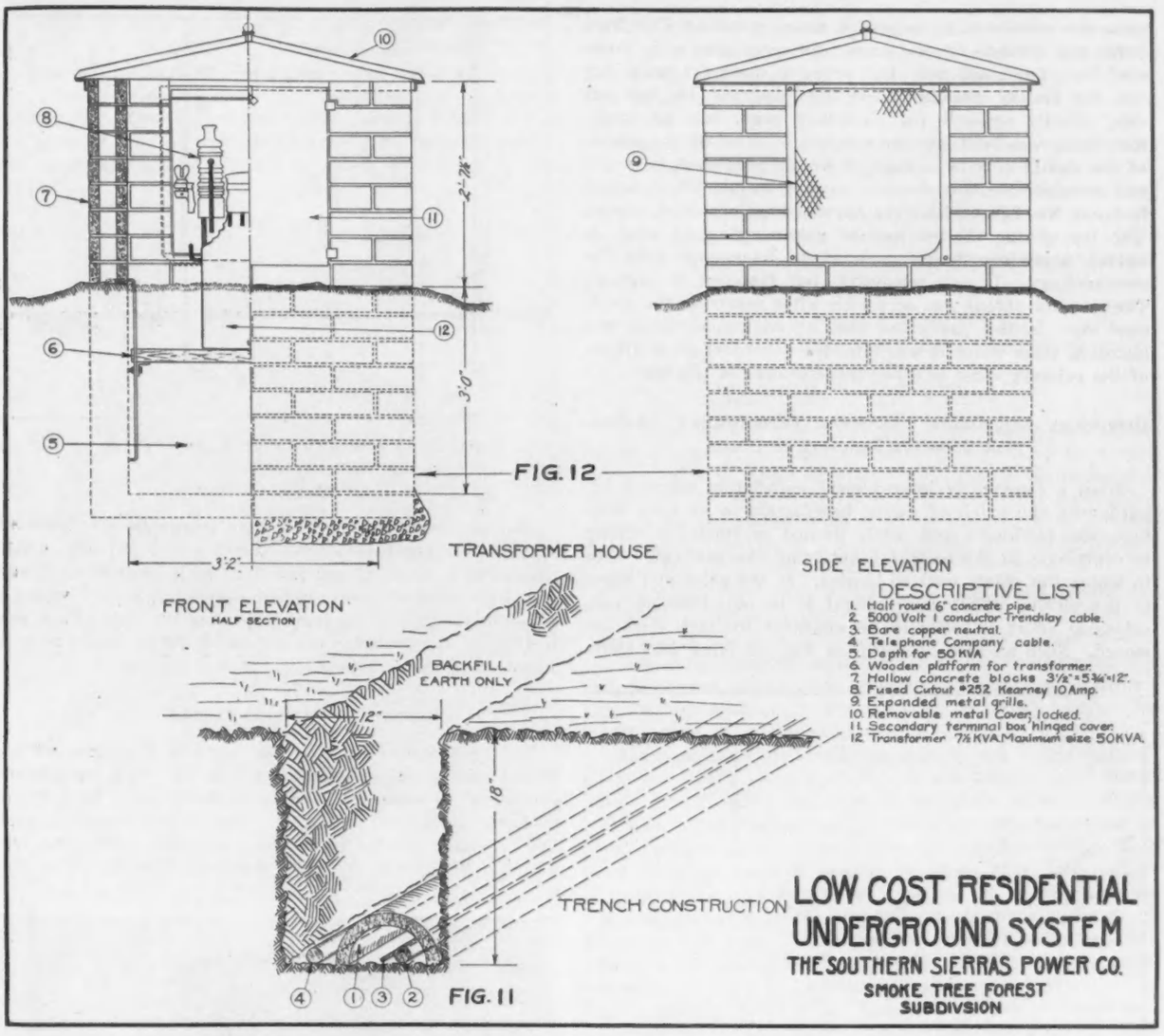
The cable from point (A) to point (B) is a four-conductor three-phase, 5,000 volt, non-metallic, non-lead sheath cable buried underground to a depth of 18 in. and is covered with a 2x6-in. redwood board, except at the crossing under Meadow Grove Ave. At this road crossing the cable is pulled through a 3-in. metal pipe. From this point (B), extending in a northerly direction, the cable is a three-conductor, 5,000-volt non-leaded cable, buried as described above and protected at road crossings by a 3-in. metal pipe. That part of the system shown along Crown Ave. was built of standard underground construction, the conductors being of lead-covered paper-insulated cable.

The pull-box, as shown on Fig. 9 at pole (B) and other locations, is made of concrete with boiler-plate lid, as shown in Fig. 10. Splices are made in these boxes for convenience in pulling cable or disconnection in locating faults. The splices are insulated with rubber, cambric and linen tape impregnated with an insulating compound. This system has been in service for a period of 1½ yr. and no trouble has developed to date.

The following low-cost underground system was installed by another of the member companies in a subdivision.

General Description

This installation consists of a 1,420-ft. single-phase primary branch from a 4-kv. grounded common-neutral overhead line to a semiexposed transformer shelter in which was installed a 7½-kva. standard pole-type transformer. The



Figs. 11 and 12—Transformer house and trench construction, low-cost residential underground system

consumer installed secondary mains and service from the transformer shelter.

Provision was made for future extension of the primary cable to other transformers in the tract. Future transformers under this project would require secondary distribution to be installed by the power company to serve individual residences. The present service is for a group of cottage-hotel buildings owned by the subdivider and is metered at the transformer.

Primary Cable Installation

The primary cable consists of a single-conductor, No. 4 strand copper, insulated with 10/64 rubber and protected by "trenchlay" type of non-metallic armor, weatherproof asbestos calks, etc. It is rated for 5,000-volt service. A No. 4 B.C. strand neutral conductor was laid directly in the ground immediately adjacent to the insulated conductor. As mechanical protection, the above phase-wire and neutral were covered with sections of standard 6-in. concrete irrigation pipe, split lengthwise as indicated in Fig 11. A one-pair, lead-sheath telephone cable was laid by the telephone company in the same trench, outside of the concrete pipe protection. Cable and neutral were carried up the line pole covered with wood molding to a point about 3 ft. below the primary crossarm, where the insulated conductor enters a fiber-conduit bend and is carried out onto the primary arm, the neutral being continued up the pole in wood molding and under the arm to connect with the line neutral. The phase conductor was connected to the line through an expulsion-type, fused cutout. It so happened that the take-off pole also carried a transformer for a pumping plant supplying water to the tract, and all three phases were protected at this point by pellet-type lightning arresters. The neutral was grounded to a ⅝x8-in. copperweld ground rod, also to the casing of the adjacent well. The neutral conductor was also grounded to a 6-in. welded steel water pipe at the transformer, the transformer shelter being located directly under a large steel water tank on a 50-ft. steel tower. The type of transformer shelter is shown in Fig. 12. It is built of sufficient size to accommodate a maximum, 50-kva. single-phase transformer. The 7½-kva. transformer, which constituted the initial installation, was supported inside the shelter on hangers, in such a position that the primary and secondary leads were above the level of the ventilating sides of the shelter. The shelter was constructed of 4x6x12-in. hollow concrete blocks and floored with the same, resting on a bed of about 4 in. of crushed rock and sand to act as a sump, the floor being sealed with concrete. Two opposite

sides are ventilated by expanded metal screens. The front panel box consists of two angle-iron rectangles with sheet-steel face, front and rear, and provides space for fused cut-outs for branch secondary circuits if desired. On the rear side, directly opposite the secondary panel box, an angle-iron frame was built into the masonry, covered on the outside of the shelter only by a sheet of No. 12 gage steel, to which was attached the transformer primary cutout, which was a Kearney No. 252 double-duty bayonet-type expulsion cutout. The top of the shelter was of galvanized sheet steel on welded angle-iron frame, painted to harmonize with the surroundings. It was removable, but fastened by padlock. The primary cutout was accessible after removing the sheet-steel top. In this particular case, an additional cutout was installed, from which it was intended to control an extension of the primary cable to other transformers in the tract.

Historical California Landmark Improvement Association Suggests Removal of Poles

Often a community improvement association becomes imbued with the spirit of public benefaction in or near some historical landmark and, while limited in funds, is willing to contribute to the cost of beautifying the particular area in which the object may be located. If the poles and wires of the serving utility are thought to be objectionable, considerable effort is made in an endeavor to have them removed. Such an area is shown in Fig. 13, lying just above

Fig. 13—Area in neighborhood of landmark where it is desired to have poles removed

and overlooking an early Spanish mission, which attracts hundreds of visitors from all over the country. In an effort to keep the costs as low as possible, the following underground scheme has been proposed.

Proposed System

Fig. 14 shows a schematic drawing of the proposed system. It is intended to run a single-phase cable from the feed point, shown on Fig. 13, to a transformer, a distance of 228 ft., thence a buried secondary system in either direction from the transformer, with secondary pull-boxes at convenient locations for extension of service laterals to each lot.

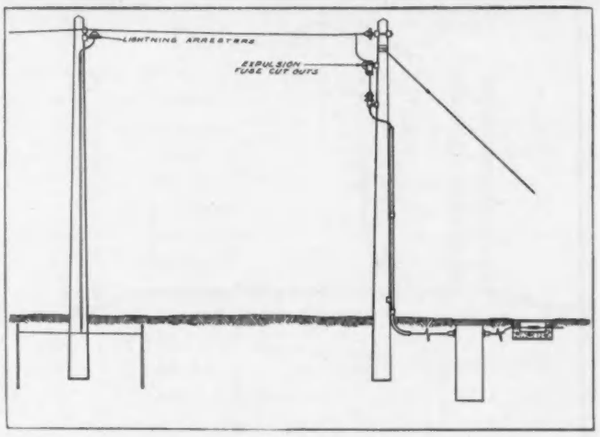


Fig. 14—Schematic drawing of proposed system

Primary System

The primary conductors will be two-conductor 5,000-volt non-metallic non-lead sheath cable, buried directly underground to a depth of not less than 18 in. and covered with a 2x6-in. redwood plank, except at road crossings where it is proposed to pull through a 3-in. metal pipe. Fuse protection for the transformer and lightning arresters is to be mounted on the feed pole and the one adjacent.

Buried Transformer Installation

The transformer serving the secondary system will be buried underground, as shown in Fig. 14. This transformer consists of a copper-bearing ⅜-in. boiler-plate tank, 27 in. in diameter, 72⅜ in. in height. Primary and secondary leads are brought into the transformer through stuffing-box-type glands. This transformer is shown in Fig. 15. The tank

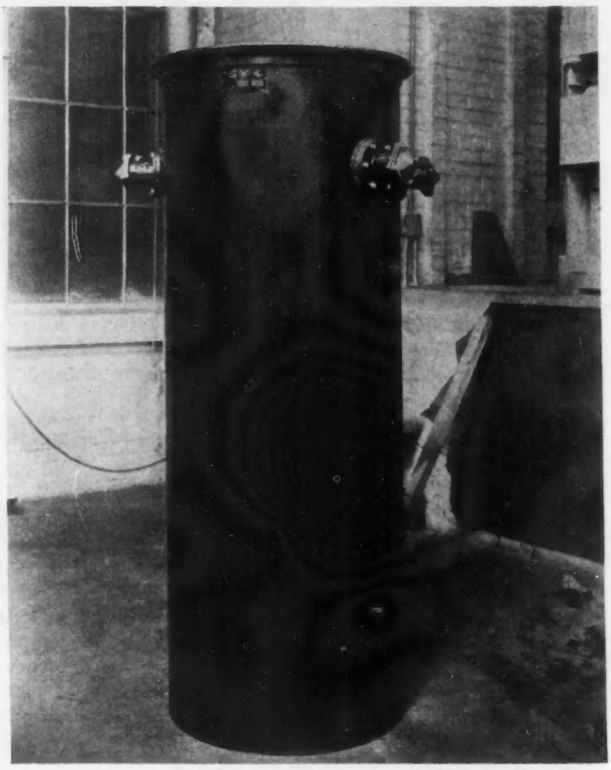


Fig. 15—Transformer serving secondary system

is sealed off from moisture by a cork gasket with studs by which a plate is securely screwed down. This is shown by Fig. 16. Around the tank just above this plate there are several holes, to allow any moisture that may pass through the upper lid of the transformer to filter out into the ground. The core of the transformer is readily removable and the tank is adapted to either 25-kva. or 50-kva. sizes.

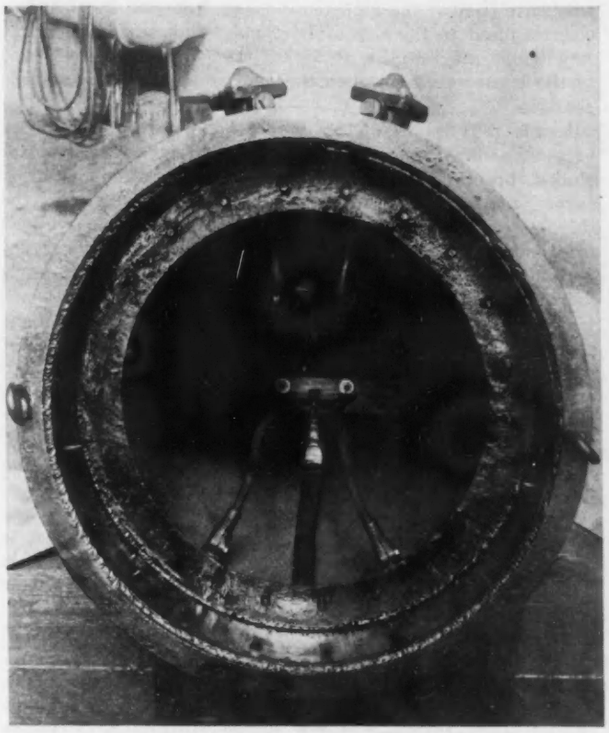


Fig. 16—The tank is sealed off from moisture by a cork gasket with studs by which a plate is securely screwed down

Secondary System

The secondary voltage will be three-wire 115/230 single-phase. Two single conductors of 600-volt non-metallic non-lead sheath cable with a weatherproof neutral will be buried along the parkway and protected as described for the primary runs. Secondary pull-boxes, as shown by Fig. 10, are to be installed at convenient points, from whence the service laterals will be extended to the consumer's property.

Conclusion

The foregoing described systems are indications that the utilities are making some endeavor to perfect a low-cost underground system to meet the demand of and promote the good will of their consumers. While they may be considered as experimental at this time, if found to afford a fair degree of service reliability, improvements will no doubt be developed that may lead to a more extended application of such systems.

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*Cause and Prevention of Manhole Explosions**

A still further reduction in the number and severity of manhole explosions can be brought about by using proper ventilation and care in operation.

THE subject of explosions in electric manholes has received some attention, not only by the power companies, but by the public as well. It is therefore important that special attention be given, in an effort to prevent such disturbances.

Explosions in manholes or under the street usually cause considerable commotion, tying-up traffic or calling out fire apparatus, which, in turn, receives the attention of the press, with the usual amplified publicity which may lead to a feeling of fear or distrust on the part of the public.

The principal cause of explosions in the underground system are:

1. Confined mixtures of inflammable gas and air.
2. Leaking gas mains.
3. Gasoline and inflammable liquids poured into the city sewers.
4. Sewer gas.
5. Gas from burning cable insulation.
6. Oil gas from transformers and switches.
7. Apparatus failure, such as short circuit.

The number and severity of explosions can be reduced by using proper ventilation and care in operating a system having substructures. Subway space should be thoroughly ventilated and construction should be such that combustible gas cannot accumulate, even in small pockets. Five-per cent mixture will explode if properly ignited, and small pockets readily collect explosive mixtures.

Gas mains break, due to street settling, and in areas affected by tides, sewer gas is forced up in the ground under pressure, naturally penetrating to the subway system. Should a cable or any subway equipment fail, the accumulated gas will ignite and the explosion follows. Carelessness in throwing lighted matches and cigarettes, by people using the streets, may cause the same results.

Many methods of ventilation are in use, using natural or forced draft. Any method that will allow a good circulation of air will soon clear the structure of an explosive mixture. Portable blowers are available when working in vaults located in gas areas to increase the ventilation, thus permitting workmen to accomplish their tasks with safety.

Periodic surveys should be made of the system, and an accurate record kept of the areas, showing the presence of explosive mixtures. These records can be checked against those taken later, when repairs are made or the source of explosive mixtures is eliminated.

The gas indicators of the filament type are the most satisfactory for making tests. They utilize the effect of combustion of flammable gas and air mixture on the surface of a glowing filament. Testing should be done only by one familiar with the instrument and its application. Care should be exercised to make sure all parts are operating properly, otherwise readings cannot be relied upon.

In furnishing uninterrupted service to consumers, it is essential that underground cables and equipment be operated with the least possible number of failures. Explosions usually mean damage to property and in turn interruption of service. This can be reduced by designing and installing a system which is properly ventilated to eliminate explosive mixtures and to dissipate heat which is generated from the equipment installed.

The frequency of manhole explosions is very low, and with using the above precautions should be still further reduced.

* Report of subcommittee on cause and prevention of manhole explosions, underground systems committee, Engineering Section. R. P. Lutzi, chairman. K. B. Ayres, N. B. Hinson, C. E. Ingalls, E. R. Northmore.

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*High-Voltage Cable**

There have been no outstanding developments in high-voltage cable during the past year; however, there are records of improvements and economy in the manufacture and an increased use by operating companies. It

* Report of subcommittee on high-voltage cable, underground systems committee, Engineering Section. E. R. Stauffacher, chairman. K. B. Ayres, R. R. Cowles, G. P. Mackenzie, J. C. Pyle, G. A. Riley.

has been the purpose of this subcommittee to watch the developments of high voltage cable and to study the records covering the operation of cable throughout the country. The nature of this subject is such that the work of the subcommittee must be confined largely to supplying information concerning cable development and use to the underground systems committee.

THE latest report on cable operation, issued by the N.E.L.A. in October, 1931, gives a most complete record of performance available at this time. It is recommended that a study be made of this publication by those interested in cable operation. The following extracts from this report cover some of the outstanding features of the experience reported by member companies:

1. The average rate of failure for high-voltage cable amounted to 6.5 failures per 100 miles per year. This was 13 per cent lower in 1930 than in 1929, and this decrease was largely accounted for by a reduction in the cable failures due to non-inherent causes.

2. About one-half of the cable failures due to non-inherent causes, which amount to 32 per cent of all cable failures, would be prevented by more care on the part of the operating companies. Based on information furnished by fourteen of the large operating companies in this country, corrosion caused 15 per cent of the total failures and mechanical damage caused 39 per cent of the total failures, these two classifications covering outstanding causes of non-inherent failures.

3. With few exceptions, the rates of failure due to inherent causes, in cables operated at 66 kv. and higher, are not much different from those for cables operating at lower voltages.

4. The largest single decrease in the rate of failures due to non-inherent causes was a reduction in the failures caused by wear at duct mouths and hangers.

5. For the fourteen companies previously referred to, 34 per cent of all failures occurred in manholes. This includes only about 3 per cent of the cable under consideration.

6. Of the 134 failures due to causes inherent in the cable, the major classifications are: 10.5 per cent due to defective sheath, 88.8 per cent due to defective insulation, and 0.7 per cent due to defective conductor.

7. For lead-covered cable buried directly in the ground, only one failure was reported in 75.5 mi.-yr. of operation. This quite definitely indicates that no unusual troubles are to be expected in this type of installation.

8. Extra high-voltage cables have an excellent record. No electrical failures have occured in 227 mi.-yr. of operation for 132-kv. oil-filled cables.

It is interesting to note that the total amount of all cable in operation at a voltage in excess of 7.5 kv. at the end of the year 1930, for 57 companies reporting was 14,063 mi. The total amount reported by 50 companies amounted to 12,510 mi. at the end of the previous year. For the 50 companies appearing in both reports, the total amount of cable in operation at a voltage in excess of 7.5 kv. was 13,962 mi. This represents an increase of 1,425 mi. or 11.6 per cent. These figures include impregnated-paper, varnished-cambric and rubber-insulated cables.

A number of recent high-voltage cable installations have been giving satisfactory service on the Pacific Coast during the past year. The 66-kv. cable installed on the system of the Pacific Gas and Electric Co. at Newark substation has, according to reports, given no trouble. The 33-kv., three-conductor type-H paper-insulated cable on the system of the Los Angeles Gas and Electric Corp. has been performing satisfactorily. This cable is 1½ mi. in length and, due to the difference in elevation of the terminals, it was necessary to install oil-stop joints. It is interesting to note that rubber-insulated cable was considered for this service, because of the difference in elevation between the terminals, but it was decided to postpone the use of rubber as an insulator for a voltage as high as 33 kv. until more information was available on the subject. The installation of four 13.5-kv., three-conductor submarine cables, each 2,750 ft. in length, on the system of the Southern California Edison Co. Ltd. at Long Beach has caused no difficulty. Rubber insulation with each conductor shielded, is incorporated in these cables and it is interesting to note that the electrical system is isolated-neutral, in place of the scheme of grounded-neutral usually employed with cables of this class. The outstanding feature of high-voltage cable operation for the past year has been the small amount of trouble experienced with its operation. A number of other utilities on the Pacific Coast, as well as municipalities, have been using high-voltage cables in the order of 33 kv. for the past several years, but so far as can be ascertained, the past year has given the least amount of trouble in operation. One of the most interesting installations of high-voltage cable is that which is in process of manufacture at this time. This is the 115-kv. oil-filled submarine cable for transmission under the Columbia River on the system of the Northwest Electric Co. at Portland, Ore. This cable is a 750,000-circ.mil single-conductor cable and will form part of the high-tension line from the Ariel hydro-electric plant to the city of Portland. It is understood that it will operate initially at 66 kv. and will be changed over to the higher voltage when the load conditions demand this change.

In the 1931 report of the underground systems committee of the Pacific Coast Electrical Assn., three papers were included, prepared by representatives of the cable manufacturers, two of which apply particularly to insulations, the third stressing the economies of high-voltage cable. No new information has been obtained from the manufacturers concerning any developments in insulation and, so far as is known, the report of 1931 will cover this phase of the work. However, a report submitted by the underground systems committee, Engineering National Section, on the subject of cable research, which was published in October, 1931, discusses certain investigations which are under way, giving the results of investigations up to this time. It is a study of the temperature and ionization effect in paper-insulated high-tension cables and it covers the influence of residual air and moisture in this same type of insulation. In addition, life studies of a number of different oils are reported upon and the development of a standard thermal conductance test is presented. It is suggested that members interested in this phase of high-voltage cables refer to this report on cable research.

At one of the meetings of the underground systems committee, Engineering National Section, D. M. Simmons, representing one of the cable manufacturers, was asked to present a brief report on European cable conditions. This report was of such general interest that it appears justifiable to include portions of it as part of this discussion on high-voltage cables. The following extracts cover some of the outstanding features:

European Cables

Types of Cable—

The focus of attention of all interested in the European cable industry is the oil-filled cable system. The most important cable manufacturers in all countries are licensed to make oil-filled cable, but so far there is not much in service. There is a little 132-kv. oil-filled cable in Italy, and some three-conductor 70-kv. cable. At Nuemberg, in Germany, a 10-km. line of oil-filled cable was installed a few years ago, and an additional parallel is to be installed this year. In England four lines are being installed in London, two at 66 kv. and two at 132 kv. Recently a considerable quantity of additional cable has been ordered in England, and in the near future, the total of English high-voltage oil-filled cable will be about as great as that in this country, unless there are further extensions here.

Another characteristic of European cables, as of our own, is the practically universal use of the type-H construction for all high voltages.

Probably the two outstanding differences between European and American cables are that the vast majority of European cables are steel-tape armored for direct burial in the ground, and the fact that their insulation thicknesses are somewhat less than our standard. It seems to me quite clear why they are able to use less insulation abroad than we do here. I believe it is primarily a question of temperature cycles and the formation of voids. In a cable in which no voids are formed, as in the oil-filled cable, insulation thicknesses can be cut at least in half. I believe that an ordinary hard-compound cable could operate with a great reduction in thickness if it were kept at a perfectly constant temperature and never allowed to form voids. There must be intermediate cases between that condition and the usual conditions, and if temperature cycles are very small, then it seems quite possible to make corresponding reductions in insulation thickness, because of reduced danger of void formation.

One result of their reduction in insulation thickness is that they are able to make three-conductor 66-kv. cable without going to excessive diameters. This is also greatly assisted by the fact that their loads are so small that their conductor sizes are small. I found, therefore, that a three-conductor type-H 66-kv. cable is quite a common article in Europe.

Another difference between European and American practice is the prevalence, and I believe increasing tendency, to use the type-SL cable, where a three-conductor cable is made up of three separately leaded single-conductor cables, which are cabled together,

rounded with jute, and then steel-tape armored. European opinion is not unanimous as to the advantages of this form, but it is claimed that there is some over-all economy, due to the possibility of using less lead and less impregnating compound, since the fillers are not impregnated. I can see little advantage in this type of cable except for buried cable. In fact, it seems to me that logically, the equivalent of type SL, for cables to be pulled into ducts, is our practice of pulling three single-conductor cables into the same duct.

I might mention briefly another cable which was quite a novelty, or rather a combination of novelties. This was a three-conductor 60-kv. cable of the SL type, with separate lead sheaths on each conductor, using large solid conductors (not stranded). It was an armored cable, and the fillers which round out the three lead sheaths were made so small that the armor took a triangular shape, thus making a slight saving in the cost of the armor. In addition to this, the filler material was of such a nature that, when a failure took place, it generated carbon dioxide and prevented, it was claimed, any explosion.

European cables for all voltages are almost always steel-tape armored and buried directly in the ground, even in the large cities. Cables in ducts are, I believe, being used more extensively recently than in the past in cities, but there is a general belief that this type of installation is more severe on the cable. For single-conductor cables, where the armor losses would be too great, they usually bury a U-shaped concrete trough, placing the cables in this trough and covering the trough with concrete slabs, the whole installation then being buried.

In any discussion of high-voltage cable, consideration must be given to the increasing importance of the oil-filled type. At present the economic dividing line is not sharply defined, as there are a number of factors involved. Such factors as the size of ducts available, voltage rating, load per circuit, single-conductor or three-conductor, all help to determine whether oil-filled or solid cable is the more economical. At present there is a rather wide overlap from 30,000 to 70,000 volts, grading off at each end, where choice is a matter of local conditions and requirements. This brings us to a consideration of the extra high-voltage cable, that is, cable operating above 70,000 volts rating, where oil-filled cable is in the lead from practically every standpoint. According to G. B. Shanklin and F. H. Buller, representing one large cable manufacturing company, some of the outstanding advantages of oil-filled cable as compared with solid cable are:

(a) Voids are entirely eliminated, if the installation is properly designed, and insulation deterioration is not a factor to contend with.

(b) Maximum safe operating temperature is higher and fluctuations in load and seasonal temperature are not important.

(c) The thickness of insulation is about half that of solid cable, resulting in a smaller, lighter cable, or for equal over-all diameters, a cable of larger conductor size and greater current-carrying capacity.

(d) For a given sized duct, much more power can be carried by oil-filled cable, for the reasons outlined.

(e) The maximum safe voltage rating for single-conductor, solid cable is about 75 kv.; oil-filled cable has extended this to 132 kv., and 220 kv. appears possible when required.

(f) The maximum safe voltage rating for three-conductor, solid cable is about 45 kv., because of physical limitations; oil-filled cable has extended this to 75 kv. and even higher voltage is possible.

(g) Positive oil pressure is maintained and because of this, flaws and defects in the lead sheath merely result in slow leakage of oil, which can be located and repaired at any convenient time. Electrical service failure, caused by entrance of moisture and air, is usually the first warning of such defects in solid cable.

The greatest criticism of oil-filled cable in the past has been its complication and the further complication introduced by certain necessary accessories, which were difficult to install and which require careful maintenance in operation. Accordingly, during recent years, the manufacturers have been making every effort to overcome this difficulty and they now promise us oil-filled cable approaching the simplicity of the installation of the ordinary type of cable. In its present form, considerable progress has been made toward accomplishing this aim of simplicity and there is a background of successful practical experience with the simplified form. According to R. W. Atkinson and D. M. Simmons, representing another large cable manufacturing company, the outstanding features of the simplified form of oil-filled cable installations are as follows:

1. Shipment of cable filled with oil, and without field evacuation and reimpregnation.

2. Stop joints of moderate size and cost, and a rapid and reliable technique of installation, making practicable oil-feed lengths as short as desired.

3. Reliable oil-feed system, including compact designs of expansion oil reservoir with oil-volume indicator, and an automatic signal system designed to give to oil-filled cable the same superiority over solid-type cable, in freedom from service failures due to mechanical causes, that it now enjoys with respect to electrical trouble.

4. For multi-conductor cable, provision of oil channels in the filler spaces, making the system equally applicable to single-conductor and three-conductor cable.

These authors further state, "These developments have made possible the realization of a unified oil-filled cable system, which involves a minimum of complications and which, in the higher voltage range, has a decided cost advantage over solid cables."

In any consideration of high-voltage cable, the question of economics must, of course, be given paramount consideration. The only justification for going to the higher-voltage underground transmission, is that of being able to transmit electrical energy under the given conditions cheaper this way than by any other means. An outstanding contribution to this phase of cable study was that of D. W. Roper of the Commonwealth Edison Co., in a paper which he presented last year. Certain of the outstanding conclusions which he reached are as follows:

1. The most economical cable for a given set of conditions should be determined by considering the total annual charges, rather than the first cost.

2. For a given type and voltage of cable, maximum economy is generally found with larger cables than those in ordinary use.

3. Three-conductor cables are the most economical for loads up to about 50,000 kva. For the upper half of this range, three-conductor, 66-kv. oil-filled cable is the most attractive, but it requires larger ducts than are now in ordinary use.

4. For loads above 50,000 kva. per line, single-conductor cable should be used.

5. For cable to operate at 66 kv., a moderate reduction in the cost of oil-filled single-conductor cable and in the cost of the joints and accessories, would bring the oil-filled type in competition on a cost basis with the cable of ordinary type.

6. For loads of the order of 100,000 kva. per line, oil-filled 66-kv. single-conductor cable is preferable to the ordinary type, when the over-all diameter of cable is limited by the size of the ducts in existing conduits.

7. As the fixed charges are about three-fourths of the total annual charges, the best way to reduce annual charges is to reduce first cost.

In concluding his paper, Mr. Roper points out what may be expected in the future concerning underground cable. These conclusions are so interesting and outstanding, that it is believed that they will furnish a fitting conclusion for this report. Under the subhead "Looking Forward," the following statements are made:

1. Cables of all types and voltages will be operated at a maximum temperature of 85 to 90 deg. C. without fear of deterioration.

2. The expensive oil reservoirs and accessories on oil-filled cable will be eliminated, due to:
   (a) Increase in the elastic limit of the cable sheath.
   (b) Reduction in the thermal coefficient of expansion of the oil.
   (c) Making the insulation somewhat compressible under moderate pressures existing with the lead sheath.

3. An installation of oil-filled cable will be no more complicated than a present-day installation of ordinary type of cable.

4. Cable of subnormal quality will be eliminated by tests at the factory.

5. The initial cost per kva. of 66-kv. cable, completely installed, will be from 30 to 40 per cent below the present cost of the ordinary type.

6. Cable failures due to all causes will not exceed one per hundred miles per year.

If all these results should be achieved within the next fifteen years, it would be no more startling than a statement of the present-day state of the art would have appeared fifteen years ago.

In order that the utilities may realize the benefits of such improvements in quality of cable, their standards of design and construction of conduits and manholes, workmanship during installation and splicing, as well as the standards of operation, inspection and maintenance, must be increased in at least the same ratio as the improvement in insulation.

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*Testing of High-Voltage Cables With the Kenotron Set**

The use of kenotron test sets has been very limited in the territory of the Pacific Coast Electrical Association. There has been only one set within the territory for the past few years, but recently another set was acquired by one of the member companies.

Certain questions have arisen in regard to the use and application of direct current in the testing of high-voltage cable. As a result of these questions, a subcommittee was appointed to obtain as much information as possible on the subject.

The following report gives a summary of the information obtained from the member companies of the N. E.L.A. It is intentionally limited to the question of how the kenotron sets are being used and does not cover the details or the description of the sets or the instructions covering the operation of the sets.

A bibliography is appended for the use of anyone who may be interested in studying the subject further.

AS A MATTER of convenience for those interested in the subject, the information on the use and application of the kenotron set has been divided as follows:

(a) Discussion of d.c. cable testing.
(b) Installation tests and proof test after repairs or service interruptions.
(c) Periodic tests; current-time measurements.
(d) Fault reduction.
(e) Precautions to be observed in the operation of kenotron sets.
(f) Summary.
(g) Conclusions.
(h) Bibliography.

Discussion of D.C. Cable Testing

Why Use D.C.?—

The question, "Why test a cable with direct current?", will naturally arise in the mind of anyone not familiar with the subject. The answer is that the only reason for using high-voltage d.c. for testing cable is to avoid the excessive charging current when testing a long cable with a.c. If the equipment is available and has the kva. capacity, it is only logical to test the cable with a.c., which is the form of current the insulation has to withstand in operation.

The power required to supply the charging current is:

$$\text{kva.} = 2\,\pi\,f\,C\,E^2$$

It will be seen that the kva. required is directly proportional to the frequency and the length of the cable and increases as the square of the applied voltage. In the case of modern high-voltage cable of long length, the equipment necessary may reach several thousand kva. It becomes a question of engineering economics whether to use d.c. or a.c. for testing and each case must be decided separately.

D.C./A.C. Ratio—

If reference is made to the bibliography, there will be noted a paper listed by Hayden and Eddy on the "Dielectric Strength Ratio between Direct and Alternating Voltages," 1923. The accepted ratio used at the present time is based on those original experiments. Little has been published since then, but it is understood considerable additional investigation has been performed and results have been reported giving a ratio from 1.6 to 3. The V.D.E. (German) specifications for 1928 give 2.0 for all types of insulation.

It has been established that the ratio varies with the follow factors:

1. *Temperature*—As the temperature increases the ratio decreases.
2. *Rate of Voltage Application*—The ratio increases with a faster rate of voltage application.
3. *Thickness and Composition*—Hayden and Eddy made tests on sheets of impregnated paper which showed that as the thickness increases the ratio decreases. Also as different manufacturers use different oils and papers, we may expect a different ratio for the same type of cable of different makers.

From the above points we can see the difficulty of establishing a definite ratio, particularly when we realize that the laboratory tests cannot duplicate the ageing of the cables in service. Then again the problem is further complicated by the introduction of the joints. We have no data as to the ratio for joints, and again the age of the joints must materially affect the ratio.

It should be clearly understood that the laboratory tests, which have established a d.c./a.c. ratio for the ultimate puncture strength between d.c. and a.c. voltages of new insulation, do not in any manner establish what d.c. voltage we should test our cables with.

A discussion from a well-known cable engineer brings this point out more clearly than any other received, and we are quoting from it in part as follows:

> My own personal opinion is that there are many companies which use too high voltages for proof-testing and have caused failures which would not otherwise have occured at all, whereas I believe that if a moderate voltage is used, it may be possible to eliminate some incipient troubles without damaging the cable. The difficulty is to state just what these limits are.
>
> If you will turn to page 35 of the A.E.I.C. specifications of July, 1930, you will find that a d.c. (or an a.c.) test of a certain value may be made after the installation of a cable is complete, during the installation of the cable, and as a proof-test as often as desired after the cable has been installed and put into service, and the test values are clearly given. I consider these test values, which are permissible under the A.E.I.C. specifications, to be decidedly on the upper side and in the range where probably more troubles are caused than cured.
>
> The ratio of 2.4 between d.c. and effective a.c. values has been pretty clearly established as being the ratio of ultimate breakdown strength between d.c. and a.c. of good insulation (paper, for instance). I think it is quite probable that if there are weak spots caused by damaged paper or moist paper, the ratio would probably be less than that. For that reason, I believe that as a searcher-out of weak spots in cables and especially in joints, the d.c. is quite effective, without going to too high values. You will note that tests of 175 per cent of rated voltage, times 2.4, would be permissible as a proof-test. I think a much more useful test would be something like d.c. value equal to double a.c. working voltage, or possibly 2.4 times a.c. working voltage. I believe that such a test would be no more severe on good cable than working voltage and yet that it would be much more effective in picking out incipient trouble than working voltage would be.
>
> In regard to the matter of time, d.c. is very different from a.c. With d.c., the voltage-time curve would be one with a curvature starting with zero time, going downward, but very soon becoming practically a straight horizontal line. In other words, the general experience has been that if d.c. is to be used, failures occur very

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* Report of subcommittee on testing of high-voltage cables with the kenotron set, underground systems committee, Engineering Section. G. L. Hill, chairman. C. E. Biggs, W. K. Cullen, H. H. Minor, Z. T. Pettit.

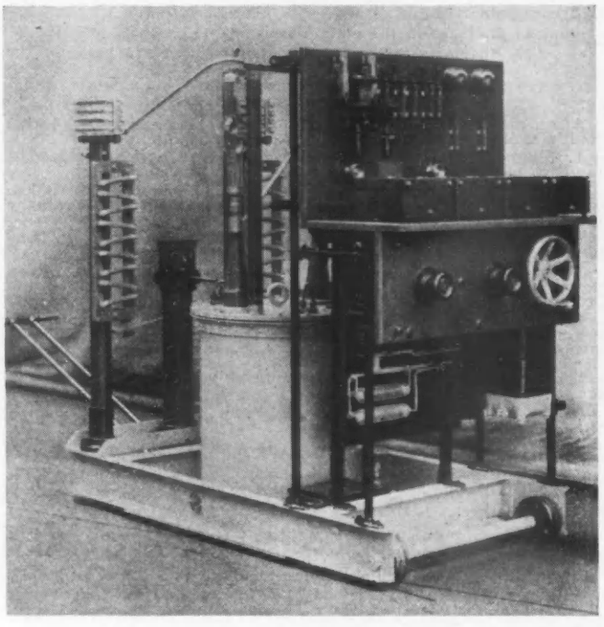

Fig. 1—D.c. cable-testing set, 100,000-volt neutral-grounded 100-milleamp.

promptly if they are going to occur at all. I think d.c. failures usually occur in the first minute or so, though I have seen exceptions. At any rate, the A.E.I.C. specifications call for a five-minute proof-test, and I think that should be your recommendation.

Tests After Installation and Proof Tests After Repairs

Tests after installation may be acceptance tests of new cable or may be tests on re-used cable re-installed in some new location. Regardless of whether new cable or re-used cable is installed, it requires some suitable high-potential test to assure that the cable has not been injured and also that the joints, potheads, bus structures, etc., are satisfactory before turning over for operation.

In some cases, no doubt, the values of d.c. to be applied in the acceptance tests are decided upon jointly by the manufacturer and the purchaser of the cable and are covered in the specifications.

Testing cable after repairs have been made is a very important test. This obviously gives a check on the repairs, and prevents a service failure when the cable is energized in case of faulty workmanship.

The information received from the various companies indicates that there is a very wide variation in test voltages applied after installation and also after repairs. Curves (1) and (2), Fig. 2, and curves (1) and (2), Fig. 3, show this wide variation of applied test potential for cables of a similar type and approximately the same nominal operating voltage. The nominal operating voltages selected for examples are 11,000, 13,200, 26,400 and 33,000.

The test potentials for the installation tests and for the proof tests are plotted on the same graph for ready comparison. It will be noted that twelve companies apply the same d.c. potential for installation tests as for proof tests after repairs, while eight companies apply a higher d.c. potential for installation tests than for proof tests.

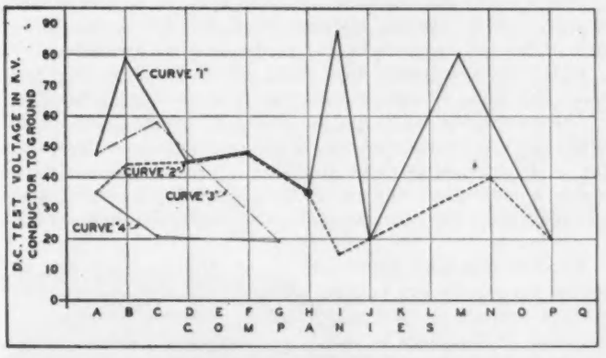

Fig. 2—D.c. test voltages used by various companies in testing three-conductor belted cable. Curve (1)—tests after installation; curve (2)—proof tests after having been repaired; curve (1) and (2)—13,200 nominal operating voltage (13,000 to 13,800); curve (3)—tests after installation; curve (4)—proof tests after having been repaired; curves (3) and (4)—11,000 nominal operating voltage (11,000 to 12,000). The circle indicates shielded.

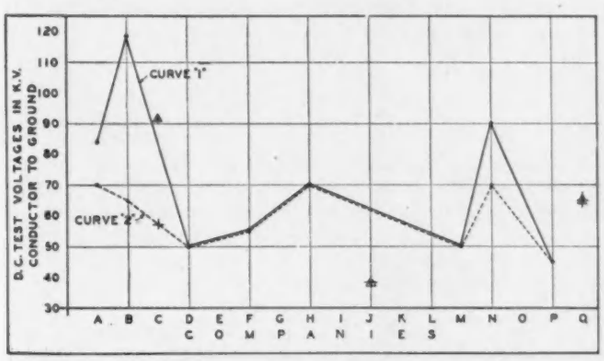

Fig. 3—D.c. test voltages used by various companies in testing three-conductor belted cable. Curve (2)—proof tests after having been repaired, 26,400-volt cable; curve (1)—tests after installation, 26,400-volt cable. Cross indicates proof tests, 33,000-volt cable; triangle, installation tests, 33,000-volt cable; circle, shielded

The majority of the companies using the same test voltage for both tests state that the reason for so doing is that in a great many cases the new cable is connected to a part of an existing cable or the line consists of new cable and re-used cable.

In quite a number of distribution circuits an underground line terminates in a riser and continues as an overhead line to some outlying destination. When this is the case, it has been reported that the leakage current over the insulators overloads the kenotron set and it is impossible to determine the condition of the cable. This is very pronounced if the line is long and if the weather is damp or foggy.

As a point of information, it is interesting to refer to Fig. 2, taking the 13,200-volt (nominal) cable as an example, and determine the d.c./a.c. (operating voltage) ratio. We find the following:

For proof testing:

Minimum d.c./a.c. ratio	1.1
Maximum d.c./a.c. ratio	3.7
Average d.c./a.c. ratio	2.5

For installation testing (new cable):

Minimum d.c./a.c. ratio	1.5
Maximum d.c./a.c. ratio	6.6
Average d.c./a.c. ratio	3.7

Periodic Tests

Some use has been made of the current-time curves as a means of fault prediction. It would be very desirable to convert weak spots in the insulation into definite faults which may be repaired and thus prevent service failures.

One of the companies reports that it used d.c. for periodic testing every six months, but finds the results inconsistent and meaningless.

Another large utility reports that it has availed itself of a portable a.c. set and has made periodic proof tests with remarkable results. Its conclusions for the a.c. periodic testing are as follows:

1. It has produced no greater total of cable failures.
2. It has resulted in more accurate analysis of cable faults.
3. It has reduced the stresses on the transmission system by reducing the number of service failures.
4. It has produced economies in repairs and in generation.

Although the above company uses the kenotron for proof testing, it does not make any mention of using d.c. for periodic testing to weed out weak spots.

Another large utility states:

> No cable in our system undergoes periodic testing. A limited number of tests made about seven years ago indicated that periodic kenotron testing did not result in a reduction in the number of service failures. It is possible some reduction would result from regular testing.

In all cases, except those three mentioned above, the answer was simply "no" in replying to the question whether the kenotron set had been used for periodic testing and, if so, whether incipient faults had been weeded out to prevent service failures.

Fault Reduction

Quite frequently, when a fault occurs in a cable, the resultant arc burns the conductor off and melts the lead sheath back several inches, if the fault current flows from conductor to ground. If the fault current flows from conductor to con-

ductor, both may be burnt off and also the lead sheath melted back due to the heat of the intense arc.

This leaves an open circuit in one or two of the conductors and a more or less high resistance path to ground. In a large number of cases, the circuit may be re-energized with the normal operating voltage without any detrimental effect, except that current will not flow through one of the conductors.

The problem then becomes one of carbonizing or "reducing" the fault by the application of a suitable test potential so that an accurate determination of its position may be made.

To obtain information on this phase of d.c. cable testing, the following question was asked the various member companies: "We are interested in determining to what extent the kenotron set may be used in "reducing" or carbonizing a fault . . . ."

Five of the operating companies report that they use the kenotron set and then switch over to a constant-current transformer. The method is to "reduce" or carbonize the fault to such an extent that the voltage of the constant-current transformer will cause the a.c. current to flow across the fault.

The following gives very briefly the various methods used and comments made by the other companies in addition to the above, reporting on fault reduction:

1. D.c. and a.c. equipment used, whichever is available.

2. D.c. and a.c. equipment used. Some time necessary to reduce faults saved by using a special high-voltage bridge.

3. Low-tension d.c. test is made, indicating whether fault is of sufficiently high resistance to warrant reduction. If the fault resistance is of the order of 50 ohms or less, the Lundin interrupter set is usually used to check the loop location. For higher fault resistances, reduction is made, using either a.c. or d.c. Where the faults are submerged in water, however, reduction to about 50 ohms is usually very difficult. We have found that kenotrons alone do not have sufficient current output to reduce completely the usual type of fault. They are generally employed to reduce faults sufficiently to permit the subsequent use of transformers for final reduction.

4. The kenotron is quite satisfactory in "reducing" faults but where an a.c. test set is available, which is the case in three of our generating stations, it is used, as the fault can be "reduced" much more quickly by this means.

5. A Thyraton set rated at 5 amp. d.c., 5,000 volts, or 10 amp., 2,500 volts, is being used experimentally to locate faults as well as reduce them.

6. The kenotron alone is insufficient to reduce the fault. We have changed to a motor-generator set connecting high-voltage d.c. in parallel and gradually increasing the current to 5 amp. Thus far it has proved to be fairly successful.

7. We use the kenotron for first stage of fault reduction. Next we use two old d.c. arc-panel sets in series, giving 4.5 amp. at 10 kv. After carbonizing with these, we can use our Lundin apparatus.

8. It is standard practice for us to test cables wherever possible with a.c. A 25-cycle test set and step-up transformer is used for reducing high-resistance faults, in order to establish a carbonized path of low resistance, so as to make use of the Lundin set.

9. When the fault voltage is decreased to about 2,000 volts, the 1,200-volt d.c. motor-generator set is paralleled with the kenotron set; the rheostats are then adjusted to give maximum current from the d.c. generator without overloading.

10. We have been able to use the kenotron set in a few cases on our paper-insulated compound-filled cable for fault reducing. We have not been able to use the kenotron for fault reduction on our oil-filled cable, as the oil runs into the fault and creates a high resistance as soon as the kenotron set is disconnected.

Precautions to be Observed in the Operation of Kenotron Sets

In the bibliography, it will be noted that N.E.L.A. Publication No. 032 is listed and has the same title as above. This is a report of the accident prevention committee and the summary of this publication is herewith reprinted:

Methods of protection against hazards in connection with high-voltage d.c. testing, are detailed in this report.

Several years' experience is the basis for the developed practices here described, which should be of value to any company contemplating the use of such cable testing apparatus.

While the hazards are not greater than with other means of high-voltage testing, their peculiar nature warrants thorough inquiry and precaution before placing the apparatus in use.

This report may be used as a guide to inquiry regarding design features which have proved desirable.

It is recommended that anyone connected with or supervising tests with the kenotron obtain a copy of this publication. The amount of energy stored in a cable, after it has been energized at 50,000 or 100,000 volts, may surprise anyone if they are near and witness its discharge. Also the fact that a long cable may regain part of its electric charge after it has been grounded, is apt to be overlooked by men versed in electrical testing.

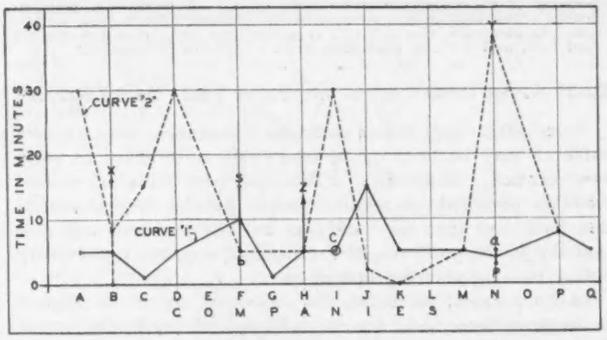

Fig. 4—Duration of d.c. tests and discharge used by various companies in testing cable with direct current. Curve (1) duration of test with direct current; curve (2) time of discharge after d.c. test; (c) current constant for five consecutive readings; (s) shielded cable; (b) belted cable; (a) acceptance tests; (p) proof tests; (x) no "time" to discharge if cable to be put back in service—"some time" if men are to work on it; (y) indefinite time, until cable is needed; (z) 5 min., if cable is to be put back in service, 2 hr., if men are to work on it

It was thought desirable to obtain information on just how long the d.c. voltages were applied and how long the cables were allowed to discharge.

Fig. 4 shows the duration of d.c. tests and the time of discharge used by various companies. Curve (1) is the duration of the tests and curve (2) is the time of discharge.

It will be noted that five of the companies discharge the cable the same length of time that they test it, while five of the companies discharge the cable for greater periods of time than the duration of test, and three companies discharge for a shorter period than the time of test. One company makes a distinction between the time of testing its belted and shielded cable, but does not make any distinction in the time of discharge.

Another company leaves the cable grounded until it is needed for service but does not say how long it discharges the cable if men are to start to work on it. Another reports that the time of discharge is instantaneous if the cable is to be put back into service, and "some time" if men are to work on it.

The duration of discharge time after a kenotron test evidently is not varied due to the length of cable, nor is it varied for different sizes of cable by any of the member companies answering the questionnaire. They did not make any distinction in the time when listing the time of discharge for various cables, but there was some distinction made by one company in the duration of test on different types of cable.

Summary

Tests After Installation and Proof Tests After Repairs—

The kenotron is used by nearly all the companies answering the questionnaire for tests after installation of new cable and for tests after repairs of cable due to service failure.

Of nineteen companies communicated with, fifteen use the kenotron, two use a.c. only, and two did not reply.

Fault Reduction—

The kenotron may be used for fault reduction, but from the reports received, it shows very definitely that it is too slow and lacks sufficient power to carbonize a fault.

A larger supply of a.c. power or d.c. power is necessary for fault reduction. It seems that each company uses whatever equipment is available, the most popular system being

a combination of kenotron set and constant-current transformer.

The use of a high-voltage bridge for fault location was given very favorable comment by two companies.

Periodic Tests—

The reports received indicate that the kenotron is used by some companies for periodic testing, but of fifteen companies reporting, thirteen do not use d.c. for periodic testing, whereas two do use the kenotron for periodic testing. It seems that it is impossible to determine the condition of the insulation of the more modern cables from the current-time characteristic.

In quite a number of cases, it has been reported that the cable has failed shortly after the kenotron was used to determine, or to endeavor to determine, the condition of the insulation.

One company reports remarkable results from a.c. periodic testing.

Precaution to be Observed in the Operation of the Kenotron Sets—

From the replies received, all the companies discharge a cable after having applied d.c. potential, but there is a very great inconsistency in the time element, some instantaneous, some one minute and one company two hours before men can work on the cable.

Conclusions—

There is no unanimity of opinion in regard to the value of substituting a d.c. potential instead of an a.c. potential for cable testing. Where the equipment is available and has sufficient kva. capacity, the a.c. form of current seems to be preferred by the companies for cable testing. The decision as to which form to use is a matter of economics.

Additional studies should be made in regard to the time required to discharge a cable or cables of varying length and size so as to render them safe to work on. From the information received, it appears that 30 min. discharge time would suffice; however, judgment must be exercised in each case.

We believe that the d.c. test voltage should be based upon the nominal a.c. working voltage, due allowance being made for the age and service of the cable and joints.

The following d.c./a.c. ratios are recommended for use in testing impregnated paper-insulated lead-covered cable. This is based upon the information received from both the cable manufacturers and the operating companies and is subject to revision as experience is gained and additional information is received:

For proof testing after repairs or service interruptions:
A d.c./a.c. ratio of 2 to 3 × nominal operating voltage.
An average ratio of 2.5 × nominal operating voltage.
For tests after installation of new cable (new cable only):
A d.c./a.c. ratio of 3 to 4 × nominal operating voltage.
An average ratio of 3.5 × nominal operating voltage.

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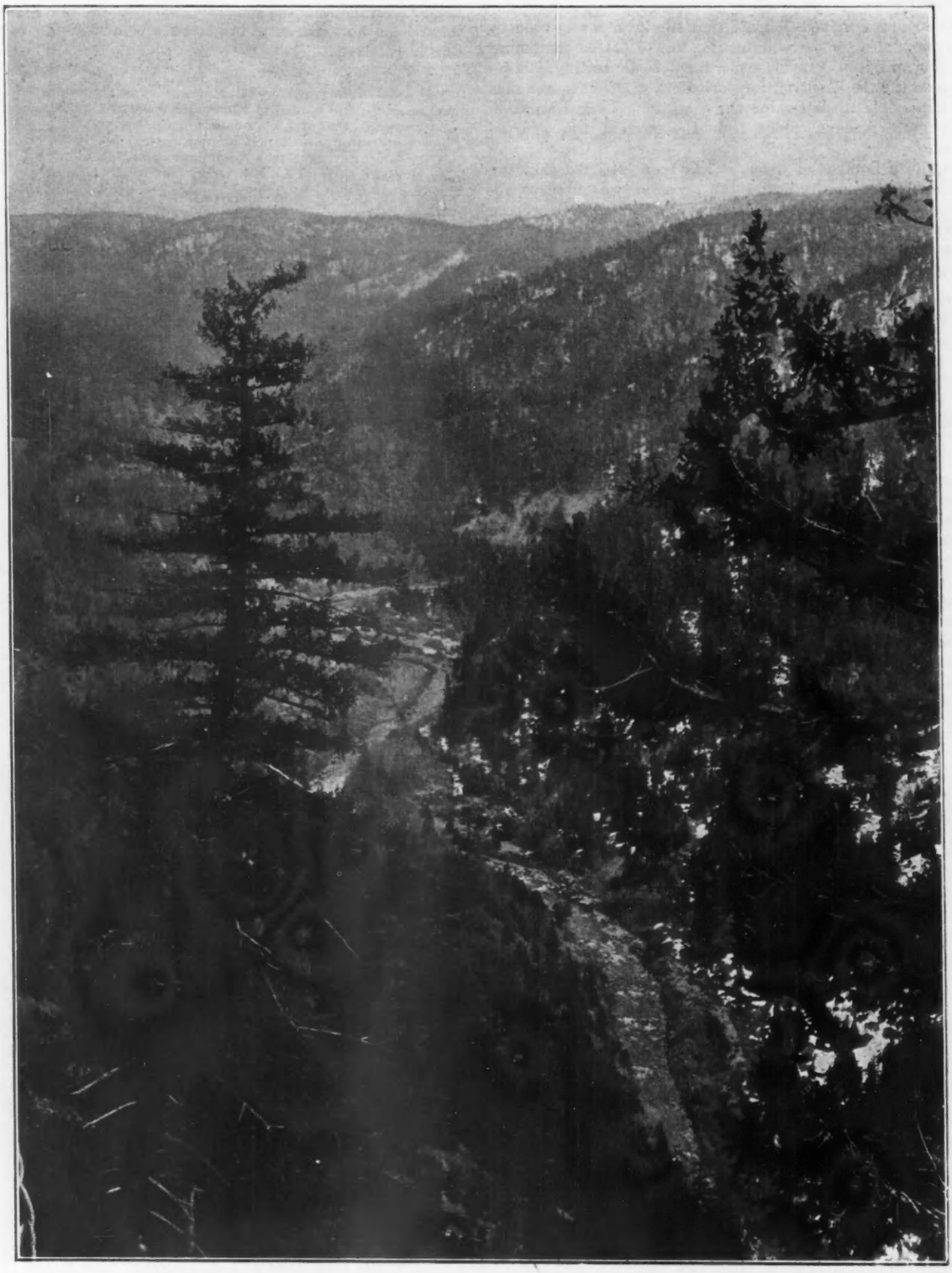


Public Relations Section[1]

*Customer Ownership**

Three member companies of the Pacific Coast Electrical Association sold stock to customers during 1931. Approximately 33,000 subscriptions were received, with an average subscription of $410 per subscriber. An unusually large proportion of the purchasers were residents of other sections of the country than those directly served by the companies concerned.

DURING the year 1931, member companies of the Pacific Coast Electrical Assn. sold under the customer ownership plan an aggregate of $13,543,575 par value of stock. Approximately 33,000 subscriptions were received, or an average of $410 per subscriber. The only companies engaging in the direct sale of stock during the year, of which this committee has any record, were the Southern California Edison Co. Ltd., Pacific Gas and Electric Co., and, to a very limited extent, the Los Angeles Gas and Electric Corp. A summary showing the sales by each of these companies will be found in Table I.

The following factors were undoubtedly influential in limiting the stock selling activities of the electric utilities operating in the territory:

(a) Reduced construction budgets.
(b) Low interest rates prevailing during the first half of 1931, making attractive the sale of senior obligations.
(c) Depressed condition of the general stock market during the latter part of the year.

It is not believed that reduced customer ownership activities reflect any doubts as to the desirability of this method of securing a portion of requisite capital funds, or of its efficacy during periods of economic disturbance. On the contrary, and having in view particularly present conditions in the financial markets of the country, it should be observed that the policy of selling stock direct to the local public was conceived and first carried into execution during a period of unusual economic stress, and that experience has demonstrated that it is possible to sell well-protected securities under this plan at times when other channels of financing are practically unavailable.

The committee again takes occasion to point out that, during periods of cessation of customer ownership activities, there usually occurs a consolidation and shifting of holdings, which tends quite definitely to reduce the number of local owners of utility stocks.

TABLE I.

SUMMARY OF STOCK SALES UNDER CUSTOMER OWNERSHIP PLAN DURING 1931

	Pac. Gas & Electric Co.	So. Calif. Edison Co.	Los Angeles Gas and Elec. Corp.
Class of stock (preferred or common)	5½% preferred	5½%, 6% preferred and common	Preferred
Par value of shares	$25.00	$25.00	$100.00
Average selling price	$25.75	5½% pref. $24.90½ 6% pref. 26.47 common 25.12	$108.00
Par value sold	$3,282,025	$10,249,250	$12,300
Number of subscribers	3,556	29,467	No information available
Average subscription	$923	$348	No information available
Approximate duration of selling campaign	Jan. 1 to May 26, 1931	Jan. 1 to April 20, 1931	No selling campaign

As indicated by Table II, the preferred and common stocks of major operating electric utilities in California were held at the close of 1931 by 236,300 stockholders, of whom 185,164 or 78.4 per cent were residents of the state. During the period from 1927 to 1931, however, there was an increase of

TABLE II.

SUMMARY SHOWING NUMBER OF STOCKHOLDERS OF PRINCIPAL ELECTRIC COMPANIES OPERATING IN CALIFORNIA, YEARS 1927-1931 INCLUSIVE

Number of Stockholders

	1927	1928	1929	1930	1931	Increase Number	Increase Percent
In California:							
Preferred	136,498	132,450	137,771	137,941	139,211	2,713	2.0
Common	37,721	36,052	39,079	45,751	45,953	8,232	21.8
Total	174,219	168,502	176,850	183,692	185,164	10,945	6.3
Outside California:							
Preferred	13,133	23,680	23,131	24,203	25,292	12,159	92.6
Common	10,628	17,451	21,094	23,097	25,844	15,216	143.2
Total	23,761	41,131	44,225	47,300	51,136	27,375	115.2
Total:							
Preferred	149,631	156,130	160,902	162,144	164,503	14,872	9.9
Common	48,349	53,503	60,173	68,848	71,797	23,448	48.5
Total	197,980	209,633	221,075	230,992	236,300	38,320	19.4

Note: Statistics covering stock ownership of the following companies are included in the above summary:
Pacific Gas and Electric Company and Subsidiaries
Southern California Edison Company, Ltd.
Los Angeles Gas and Electric Corporation
Coast Counties Gas and Electric Company
San Diego Consolidated Gas and Electric Company
California-Oregon Power Company

[1] Executive committee— W. C. Mullendore, chairman. A. M. Frost, G. A. Campbell, E. H. Coe, A. B. Day, W. H. Fischer, A. F. Hockenbeamer, W. F. Raber, A. B. West, A. E. Wishon.
Industrial relations committee—W. L. Frost, Southern California Edison Company Ltd., chairman.
California Electrical Construction Company: C. L. Chamblin.
General Electric Company: R. M. Alvord.
General Electric Supply Corporation: D. E. Harris.
Graybar Company: H. L. Harper.
McGraw-Hill Company of California: G. C. Tennev.
Newbery Electric Corporation: G. E. Arbogast.
Pacific Gas and Electric Company: R. E. Fisher, A. M. Frost.
Valley Electrical Supply Company: H. H. Courtright.
Westinghouse Electric & Manufacturing Company: A. E. Hitchner.
Relations with financial institutions committee: A. F. Hockenbeamer, Pacific Gas and Electric Company, chairman.

* Report of committee on customer ownership, Public Relations Section. E. J. Beckett, Pacific Gas and Electric Company, chairman.
Central Arizona Gas & Electric Company: C. A. Hulse.
Los Angeles Gas and Electric Corporation: F. E. Seaver.
San Diego Consolidated Gas & Electric Company: M. B. Fowler.
San Joaquin Light & Power Corporation: W. E. Durfey.
Southern California Edison Company Ltd.: F. L. Greenhouse.
The Southern Sierras Power Company: A. S. Cooper.

only 2,713, or 2 per cent, in the local holders of the preferred stocks of these companies, while non-resident preferred stockholders increased 12,159, or 92.6 per cent. With respect to ownership of both preferred and common issues, there was an increase of 10,945, or 6.3 per cent of the number of local investors in these securities during this period, and of 27,375, or 115.2 per cent, in the number of non-resident stockholders. While this situation affords a rather flattering indication of the regard in which the securities of California utilities are held by investors in other sections of the country, it also reveals a trend of stock distribution adverse to the policy of local ownership, which has been for many years so important a factor in the development of the electrical industry.

*Employees' Speaking Contest**

The public speaking committee this year reports a more active interest than ever before in the presentation of the public utility story before meetings of citizens. Continued participation in the N.E.L.A. employees' speaking contest is recommended, although it is advised that the rules under which it is conducted be somewhat modified.

THERE are two activities which come under the province of the public speaking committee. The first is to stimulate contacts on the part of utility representatives at meetings of clubs, schools and the like and to keep a record of these appearances. During the calendar year 1931, the representatives of member companies of the P.C.E.A. spoke at 1,020 meetings, with a total attendance of 226,529. This is a decided improvement over the report for 1930, which showed a total of 194 meetings and an attendance of 13,265.

The commi.tee recognizes the value of these contacts and recommends a continued effort along the same direction.

The second activity of the public speaking committee and the one which is more widely known, is that of supervising the employees' speaking contest, as sponsored by the N.E.L.A. This year there has been a wider interest in the speaking contest than in previous years and the quality of the addresses generally is of a higher standard than in any previous contest. The following tabulation shows the number of men and women appearing in the preliminary elimination contests conducted by the several companies.

EMPLOYEES' SPEAKING CONTEST

Company	Men	Women	Total
San Joaquin Light & Power Corp.	16	3	19
Coast Counties Gas & Electric Co.	9	—	9
Pacific Gas and Electric Co.	50	12	62
Arizona Utilities Association	(not reported separately)		20
Southern Sierras Power Company	43	9	52
Los Angeles Gas and Electric Corp.	52	5	57
Southern California Edison Co. Ltd.	58	22	80
			299

The committee recommends that the Pacific Coast Electrical Association continue to participate in these contests sponsored by the N.E.L.A. At the same time the committee recommends that serious attention be given to a further revision of the rules, which still appear to be cumbersome in some respects. It is believed that less rigid rules would promote a still wider interest in the contest, in the earlier stages at least.

* Report of employees' speaking contest committee, Public Relations Section. R. E. Smith, chairman.
Central Arizona Light & Power Company: A. F. Morairty.
Coast Counties Gas & Electric Company: Pierre Vinet.
Los Angeles Gas and Electric Corporation: D. L. Scott.
McGraw-Hill Company of California: G. C. Tenney.
Pacific Gas and Electric Company: Al C. Joy, W. A. Worthington.
San Diego Consolidated Gas & Electric Company: F. M. Raymond.
San Joaquin Light & Power Corporation: A. D. Church.
Sierra Pacific Power Company: O. S. Clifford.
The Southern Sierras Power Company: W. S. Boggs.

*Women's Committee**

The women's committee of this year has fostered the study among women employees of public relations subjects, has promoted interest in matters relating to health, safety and first aid, has prepared a lecture on the electrical industry for delivery before women's clubs, has built up a bibliography of articles from current magazines on subjects of electrical interest, has published a monthly bulletin and secured wide participation among women employees in the speaking and essay contests. The committee has functioned this year as a single unit with the women's committee of the Pacific Coast Gas Association.

DURING the current year, the women's committees of the Pacific Coast Electrical Assn. and the Pacific Coast Gas Assn. have operated as a single unit. Plans for the year's work were developed at a meeting held at the time of the P.C.G.A. convention at San Francisco, on Sept. 2, 1931.

The year's plans, as adopted at the San Francisco meeting, were stated under two captions, "women's committee objectives" and "women's committee program." These follow in full:

WOMEN'S COMMITTEE OBJECTIVE 1931-32

1. To study and understand the policies and practices and relationships of the company.
2. To study and understand the place of the public utility in the life of the community, and its relation to governmental bodies and the public generally.
3. To develop and improve the morale of the women employees of the company, and assist them in acquiring an attitude of complete accord with the entire organization; and to promote acquaintanceship and good fellowship among the women themselves.
4. To select and train women employees of special aptitude for volunteer service in representing the company before outside groups of women.

WOMEN'S COMMITTEE PROGRAM 1931-1932

1. *A Program of Meetings—*
   (a) Public utility economics and public relations to receive major attention.
   (b) Utilization problems—new appliances, etc.
   (c) Entertainment features to garnish the program.
   (d) Opportunity for individual members to participate.
2. *A Social Program—*
   (a) The promotion of good will and acquaintance among women employees by whatever means are most adaptable and applicable to the local situation.
3. *A Self-Improvement Program—*
   (a) A study of public utility economics, policies and practices, by means of lectures, classes, reading courses or other available means.
   (b) Study and promotion of health of members by local committees.
   (c) Study of safety and first aid methods.
   (d) The providing of adequate vocational guidance and counsel.
   (e) Cooperation with the employee educational program of the association.
4. *A Public Relations Program—*
   (a) Study of the feasibility and desirability of preparing, cooperatively, an illustrated lecture each year, which may be delivered before women's organizations by selected members of the women's committee.
   (b) To study the problem of interesting the women relatives of employees in the formation of clubs, either in combination with the women's committee, or separate from it, for the purpose of cultural development and the nurture of company spirit.

* Miss Clarita Scott, Los Angeles Gas and Electric Corporation, chairman.
Arizona Edison Company: Miss Wilma D. Jones, chairman. Miss Genevieve Callahan, Miss Margaret Caywood, Mrs. Anna Gilbert, Mrs. E. H. McGill, Miss Edwina Stites.
Arizona Utilities Association: Mrs. Jean Roberts.
Central Arizona Light & Power Company: Miss G. B. Price.
Coast Counties Gas & Electric Company: Mrs. Margaret Menke.
Los Angeles Gas and Electric Corporation: Mrs. Marvel Murray.
Pacific Gas and Electric Company: Miss Bertha Dale (includes fourteen divisional subcommittees).
San Diego Consolidated Gas & Electric Company: Mrs. M. C. Lynn.
San Joaquin Light & Power Corporation: Miss Clyda Weems.
Southern California Edison Company Ltd.: Mrs. Jeanette I. Rees, chairman. Mrs. Amber Andersgaard, Mrs. C. L. Ashley, Miss A. L. Bidwell, Mrs. Ethel Brown, Mrs. Eulah Heddon, Miss Lois Packard, Mrs. Anita Walker.
The Southern Sierras Power Company: Miss Olivia Jacobson.

5. *Committee Management Program—*

(a) A study of the functions and methods of organization, through conference of the women's committee chairmen at the convention, and upon such other occasions as may present, and through the exchange of opinion and experience in the women's committee bulletin.

Accomplishments So Far

The adopted program has been followed by the general committee and the individual company committees with commendable fidelity. The year's over-all objective has been to conduct a campaign of education on these subjects commonly grouped under the caption of "public relations."

A uniform course of study is being promoted through the columns of *Public Utility Women*, the medium of communication between the chairman of the general committee and the chairmen of the company committees. This course of study is presented in a series of articles, some prepared by the chairman and some by company executives who have graciously assisted in the work, dealing with the various themes for study, and accompanied in each case by a set of questions for the testing of the members' knowledge. (Some of the company committees are offering competitive prizes to their members, based upon examinations in these subjects.)

The study themes for the year follow in order:

October—"Rates."
November—"Courtesy."
December—Christmas Program.
January—"Self-Improvement."
February—"Regulation."
March—"Theories of Ownership."
April—"History of the Electrical Industry."
May—"Company Financing."
June—"Taxation."
July—Vacation.
August—Vacation.
September—"My Company's Customer Relations."

The subcommittee on safety and first aid, under the chairmanship of Mrs. Beulah Brown, has been active during the year. Mrs. Brown has issued bulletins to the company chairmen, and contributed articles for publication in *Public Utility Women* on subjects relating to health, safety and first aid. She has succeeded in organizing classes in first aid in her own company (Pacific Gas and Electric Co.), and has received some encouragement that classes will be organized in other companies as soon as the present educational activities are finished. Her letters and bulletins have given valuable information on these important subjects to all women's committee members.

Mrs. Jeanette I. Rees, chairman of the subcommittee on illustrated lectures, reports that her lecture on the electrical industry is nearly finished. This lecture is to be written for delivery to women's clubs, P.T.A.'s, etc., and will be suitably illustrated with stereoptican views. It is to be written primarily for those who are not familiar with the industry's story, but will undoubtedly be used extensively by the women's committee themselves.

The current literature subcommittee, of which there are four divisions (each subdivision having the assignment to report on three or four magazines each month), has been very active. Each issue of *Public Utility Women* has carried a list of articles pertinent to the industry itself or on some commercial or public-relations theme which would benefit public utility employees.

Public Utility Women

Public Utility Women, issued once each month, carries all committee news and is the medium for exchange of ideas and opinions. The reports of many of the company committees appear in these monthly bulletins, which give an idea of the individual committees' work which is not within the scope of this general report.

Participation in Association Activities

The women's committee is taking active part in the speaking and essay contests. It is too early to make an accurate report of the number entering these contests, but it is believed that many more women are participating than ever before. Each chairman is given the responsibility of promoting these contests among the women, as an aid to the company contest director, using the bulletins and group meetings as a means of promoting interest and enthusiam.

Plans for the Future

The final meeting of the committee for this year will be held at the P.C.E.A. convention. A half-day program, devoted to the problems of committee management, is being planned; also a business session of the general committee. The time is too far distant to give the details here. But we hope to make these meetings produce much that is good.

An exhibit of women's committee work for the year will be held at the convention. Each company committee will prepare its own exhibit. These exhibits will be judged from the standpoint of work accomplished, and on the following points: regularity of meetings, educational value of activities, social value of activities, balance and variety of programs, promotion of committee activities, and the appearance and style of the exhibit. Prizes will be offered for the highest grade of work.

Organization

There is no roster of membership of the women's committee. Every woman employed in the electrical industry is considered a member of the committee. In addition to the company committee chairmen given in the committee list, the following committees should be noted.

Home Service Committee—Miss Wilma D. Jones, chairman.

Illustrated Lectures Committee—Mrs. Jeannette I. Rees, chairman.

Safety and First Aid Committee—Mrs. Beulah Brown, chairman.

Current Literature Committee—Group A, Miss Bertha Dale; Group B, Miss Clyda Weems; Group C, Mrs. Marvel Murray; Group D, Mrs. Jeannette I. Rees.

Acknowledgement

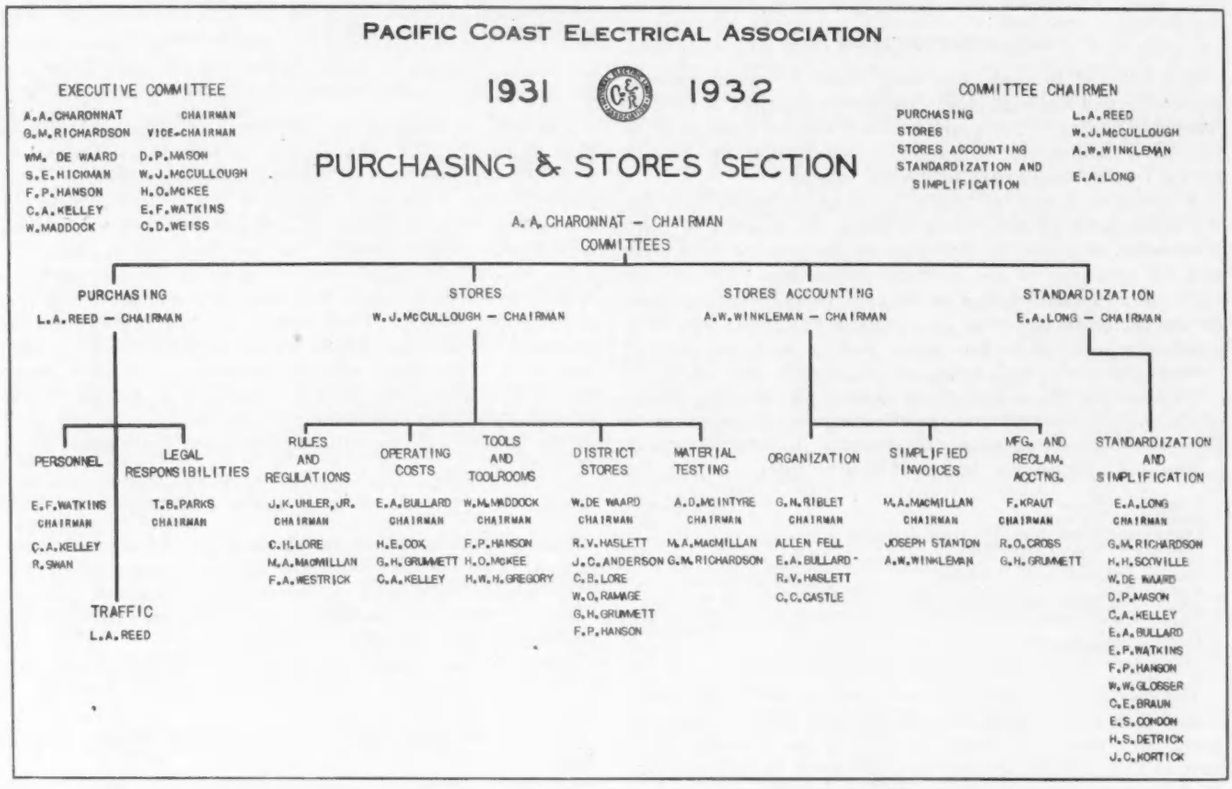
It is difficult to express full appreciation to all those who have helped in the promotion of women's committee work without seeming to resort to hyperbole. The executives and company officials of the various companies have given liberally of their time when requested, and have never failed in their interest. They have counselled and helped in every way possible, and it is through their sympathy and understanding that the chairmen have been able to convert the year's plans into accomplishment.

The chairmen have been tireless in their promotion of employee education and employee relations. It has been a year of concentrated effort and they have never faltered nor failed to give the very best programs obtainable, to arrange for athletic and social activities, and to welcome and help the "new girls" in their organization. They have cooperated with the several chairmen and with one another perfectly. The highest praise and most sincere thanks are due them for their splendid work.

K. I. Dazey, executive secretary of the Pacific Coast Electrical Assn., has been very sympathetic and helpful. He has never turned down a single request for help, for which the committee is thankful.

Addison B. Day, president and general manager of the Los Angeles Gas and Electric Corp., of which the general chairman is a member, must be mentioned for his hearty cooperation, ready sympathy, and thorough understanding of the aims and objects of the committee. He has not only given of his time, but has allowed the general chairman time for such absences from her office as were necessary, and has in every way encouraged and helped her in her work; and she is deeply grateful.

Purchasing and Stores Section[1]



The various committees of the Purchasing and Stores Section were active as usual this year, but it was decided to circulate the reports in mimeographed form instead of printing them at this time. A chart of the personnel of the section is given herewith in place of the usual committee lists.

[1] Executive committee: A. A. Charonnat, chairman. G. M. Richardson, vice-chairman. Wm. DeWard, F. P. Hanson, S. E. Hickman, C. Kelley, Wm. Maddock, D. P. Mason, W. J. McCullough, H. O. McKee, E. F. Watkins, C. D. Weiss.

Transportation Section[1]

*Section Activities**

The advantages of centralized control and of closer contact between manufacturer and customer are pointed out.

IT was the intention of this section this year to analyze several major problems of motor transportation, on which, due to demand for further economies, closer scrutiny and more intensive study was necessary than had been accorded heretofore.

During the year important subjects have been brought to the attention of various members, which have required immediate investigation and study. The first of these was the reducing of the cost of accidents in the various companies. They believe that a careful study of the fleet operators' experiences should be compiled, which, they feel, will be of material help to the men in charge of public utility fleets.

It is recognized that certain features of company organization, particularly in some of the concerns which have automotive activities spread over a wide area, render an ideal system of centralized automotive control very difficult.

The summary given below presents some of the more important advantages of centralized control, and suggests a definite procedure for the realization of such control:

Advantages of Centralized Control

(A) Reduction of Capital Expenditure—

1. By centralized purchase contracts, based on consolidated commitments and large savings by quantity purchases.
2. By parts and equipment inventory reduction.
3. By standardization of types of equipment for specific duties, and a consequent reduction of the number of truck sizes used.
4. By standardization of make of equipment, and consequent reduction of the number of makes used.
5. By ability of central control to interchange equipment between departments and reduce idle time of equipment and miscellaneous expenditures.
6. By proper control of routing and assignment of equipment to meet the requirements of various localities.
7. By possibility of pooling transportation and mainte-

[1] Executive committee: E. C. Wood, chairman. W. J. Schaeffer, vice-chairman. A. J. Aschoff, P. H. Ducker, S. B. Shaw, J. M. Wainscoat, C. D. Weiss.

* Report of chairman, E. C. Wood.

nance activities in specific territories through coordination of activities, which can only come through centralized control.

(*B*) *Reduction of Operation Expenses*—

1. By centralized purchasing.
2. By reduction of superfluous overhead.
3. By districting equipment by make of truck, in order to simplify maintenance and operation.
4. By standardization of service policies and shop procedure.

(*C*) *Facilitation of Executive Supervision*—

1. By more efficient handling of motor transportation problems, which have become such a large and such a technical and complex factor in the operation of many large industries as to demand the same type of centralized control which is exercised over other important departments of the business, such as merchandising, production, etc.
2. By educational activities to overcome antiquated and expensive practices.
3. By standardization of transportation cost accounting which will permit of the experience of one unit or subsidiary being cited for the benefit of other units, without costly experimentation on the part of other units.
4. By exercise of closer scrutiny and improved judgment in replacement of worn-out or unsuitable equipment, because of broader perspective furnished by uniform cost system, and centralized executive control. This ever-present problem is one demanding keen analysis and a high degree of coordination and control, if wasteful practices are to be avoided.

Ideal Organization and Procedure

For many and obvious reasons an ideal motor transportation set-up cannot be installed hastily. Such an ideal program should be planned for, however,—and used with such modifications as may become necessary, as a goal toward which to work. This goal should be thoroughly understood and "sold" to the organization.

Clear and explicit definition must be made of the responsibilities, relationsihps and authorities of all concerned.

The responsibilities of the supervisor of motor equipment should embrace the items enumerated in the last section of this paper. Central control must prescribe and codify the rules under which motor transportation in all branches and subsidiaries should operate, i.e., the rules by which the actual operating personnel must be guided. To the supervisor of motor equipment must be delegated ample authority to carry out the above responsibilities. The man in control of each subsidiary unit should be notified as to his exact status, and full cooperation requested.

Purchasing the Right Unit

Failure of the manufacturer to sell and of the transportation executive to buy the transport unit most scientifically adapted to predetermined requirements is admittedly of such consequence as to need no elaboration here. To state a well known fact is simple. To suggest an infallible remedy is probably impossible. But to recommend a constructive procedure which will be helpful is very much in order.

Obviously, the installation of the proper unit depends upon a clear and explicit understanding between the buyer and the seller as to all of the facts of the case, and implies a technical ability on the part of both buyer and seller, to properly interpret the facts in terms of the unit most suitable.

Trends in Design

One of the most important relationships which can exist between the transportation executive and the manufacturer has to do with motor vehicle design trends. The importance of this subject is self-evident. Suffice it to say, that the manufacturer who can more accurately forecast design trends, so that he may be in a more favorable position to know just what to build, is fortunate indeed.

We firmly believe that considerable of the guess work which must prevail under present conditions, can be eliminated. By all means, there should be closer contacts in matters of transportation and design research. For one thing, it is incumbent upon the manufacturer to insist upon his engineers and service managers spending more personal time with transportation departments, both large and small. Inadequacy of such contacts in the past cannot be properly explained away. It is true that the engineer, calling upon a great number of buyers in many different vocations, will receive many conflicting and contradictory statements. He will nevertheless observe trends, and will receive many a splendid suggestion from the operating man.

The recommendations which have already been made by certain associations (such as the Pacific Coast Electrical Assn., National Electric Light Assn., American Petroleum Institute, Society Automotive Engineers) are of great importance to the manufacturer. If, in addition to the engineer's personal contact with the customer (and this, of course, refers specifically to the transportation executive) he would use his influence toward the more specific statement by some of these associations of their design problems, a great benefit would obviously result.

We believe that the procedure recommended above would eventually impress the manufacturer more thoroughly with the necessity of instituting basic systems of design, which would permit far more flexibility in respect to public utility needs, and at the same time would minimize the manufacturer's internal problems of inventory and manufacture.

The manufacturer for years has been selling what he terms a "line." This line is composed of "models." After all is said and done, the use of the word "models" implies a certain fixity or restriction of design, a "take it or leave it" idea. If the broad conception of what constitutes a "line" of motor vehicles were enlarged, to the extent of eliminating models as such and substituting therefor a system of major units, which, through the basic design idea, can be assembled into any combination within reason to suit the customer's requirements, the result would be twofold. The transportation department would benefit by designs which more nearly meet the exacting requirements of his particular operation; the manufacturer would benefit through increased economies of tooling-up expense, of inventories and of manufacturing process.

Transportation executives, by more definitely crystallizing statements of their operating requirements, can present such a united front to the manufacturers as to permit the latter to produce designs which will be simpler, more flexible and possessed of inherent economies which will benefit the entire industry.

ORGANIZATION DIVISION REPORTS[2]

Progress has been made by this committee in the preparation of a set of rules, tests and regulations for drivers.

A set of standard drivers' examination requirements, consisting of driver's ability, physical condition and general knowledge of the Motor Vehicle Act and city ordinances and respective company rules pertaining thereto, is in the course of preparation for presentation during the coming year.

*Training and Selection of Drivers**

The careful selection of chauffeurs and truck drivers is a matter which involves the possibility of considerable saving to the public utility, as well as an improvement in public relations.

THE question of training and selecting drivers of motor vehicles is one to which we believe enough thought is not ordinarily given. Almost everybody nowadays can drive an automobile, and for this reason there is a tendency to minimize the qualifications which a successful chauffeur or successful truck driver should have. Basically, the qualifications for chauffeur or truck driver are about the same, but the two jobs demand men of different temperaments and physiques. We will discuss briefly both types.

The basic thing in selecting men for either kind of job is that they be steady and alert mentally and fit physically.

As regards their physical condition, some companies go so far as to have all prospective motor vehicle operators examined by a competent physician to determine if their eyesight, hearing and heart action are satisfactory. This physician's examination may seem unnecessary to some, but on the other hand, it is easy to picture what an accident could occur if an operator's vision were badly impaired, or if the operator were to have an attack of heart failure while at the wheel of his vehicle.

All operators should have somewhat more than a superficial knowledge of the mechanics of their units, and should be competent to care for minor and roadside repairs. The more competent the operators mechanically, the better service they will get from their vehicles, and this in turn will materially reduce operating costs and accidents.

Courtesy at all times is absolutely necessary. The operator must also remember that he is the skilled man, responsible for the safety both of the pedestrian and the motor equipment. This latter thought applies particularly where changes are made which, in the driver's judgment, should not be undertaken. Under these conditions, the driver must possess both executive and diplomatic qualifications which will make him master of the situation without arousing resentment.

As regards heavy-truck drivers, we have always believed that there is a tendency on the part of some employers to minimize the responsibilities which these men carry and not to appreciate the really tremendous potential possibilities of damage which the man at the wheel of a truck carries with him. A heavy-duty truck, laden to capacity, will weigh, gross, anywhere from 10 to 12 tons, and such a unit is a literal juggernaut of death, unless properly handled and controlled. As a consequence, the responsibilities which the driver of a heavy-duty truck carries are very real, and are something which he himself must appreciate and which the management should also appreciate.

One of the biggest points in handling heavy-duty equipment is the fact that, while we know we can get any speed we want with the use of compounds and gear ratios, practically nothing has as yet been devised for quick decelerating of high speed. The engine is the best brake which the truck driver can have, but here again the driver must be thoroughly trained as to how to use his engine, and never to take chances. Nothing is more dangerous than the practice some drivers occasionally have of coasting down hill with the gears in mesh and the clutch out, and then attempting to decelerate the truck by slipping in the clutch. Sometimes the truck's mechanism will withstand this, but usually everything lets go and, even if no one is hurt, there is an attendant repair bill.

Another big point to be remembered in choosing truck drivers is that, from the minute the driver leaves his headquarters with his load, he is to all practical purposes a non-supervised employee. In addition, if incompetent or improperly instructed drivers are put on the road and have frequent road breakdowns which they are unable to handle, there is always the attendant loss of time and money to the companies. In selecting and training engineers, the railroads of the United States always stress the point that the engineer is the sole custodian of thousands of dollars worth of equipment and of numerous lives, and we believe this point should be realized among motor-vehicle operators.

Organizations reporting on this subject say that courtesy of the road is essential, that the driver must know his vehicle so far as mechanical conditions are concerned, and that present-day traffic conditions are such that every driver must be trained and must be physically and mentally fit in order to be considered a safe driver.

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*Personnel of the Transportation Department**

This subcommittee conducted a study of the personnel of various member companies during the year, with the idea of reducing overhead in transportation departments.

THE personnel heading the various subdivisions forming the transportation organization are as follows:

Superintendent, day shop foreman, night shop subforeman and chief clerk.

The superintendent is the executive head, and directs all activities through the foreman and chief clerk, both of whom report directly to him.

The foreman has complete supervision over shop crews and is directly responsible for the maintenance and efficient operation of the shops and equipment.

The superintendent is responsible for overseeing all costs. His first and most important duty is to make sure that there are no unnecessary delays in getting equipment away on time in the morning, through fault either of driver or condition of equipment. He checks drivers and operators as to their ability, both in handling equipment and in performing work satisfactorily to foreman of crew; watches for overloads and other abuses of equipment; investigates necessity for special equipment such as material and tool boxes and other accessory equipment requested by heads of other departments;

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[2] V. Dennis, Pacific Telephone & Telegraph Company, chairman.
Los Angeles Gas and Electric Corporation: W. J. Schaeffer.
Pacific Gas and Eelectric Company: E. C. Wood.
Portland Gas and Coke Company: H. W. Drake.
Southern California Edison Company Ltd.: W. H. Bauer, P. H. Ducker, E. M. Rondot.
Southern California Telephone Company: W. Fairbanks.

* Report of educational committee, organization division, Transportation Section. H. W. Drake, chairman.

* Report of subcommittee on personnel, Transportation Section.

makes sure that equipment assigned is best suited for work performed; keeps in close touch with the equipment in regard to mechanical and operating efficiency.

The chief clerk reports directly to the superintendent of transportation. He has charge of the transportation department office and is directly responsible for all office routine, which includes timekeeping, charges for transportation equipment, material ordering, stock room, all records and cost statistics; he assigns and directs operations of emergency automotive and power-operated portable tools; directs operation of all equipment assigned to delivery of materials for all departments; compiles and furnishes statistical data when required.

The authorization for permanent assignment of transportation equipment is first obtained by department heads from the manager or superintendent. When approved, the superintendent of transportation cooperates with the department head desiring equipment, and assigns available, or orders new, equipment best suited for the work proposed. When equipment is ready for service which requires a truck driver, which is usually necessary for all trucks of two-ton capacity or over, the transportation superintendent hires the truck driver, who remains on the transportation pay roll and is responsible to the superintendent for the efficient operation and care of his truck.

Every operator or truck driver to whom has been assigned automotive equipment must secure a Daily Operator's Card and register at the time he leaves the garage with equipment. The operator must, without fail, insert odometer or speedometer readings at start and finish of each day's run, and properly fill in other data provided for on the card, such as date, mileage, repairs made enroute, repairs needed, job number, time arrived at job, time left job, for the guidance of repair shop crews in matters concerning repairs and maintenance work, and the office force.

The night shop assistant foreman has under his direction repair men, service crews and washers, on duty in two shifts, from 5:00 p.m. until 7:00 a.m. He inspects all Daily Operator's Data Cards and directs repair work reported by operators and drivers as being needed. He personally makes mechanical inspections of all equipment and arranges for light repair work, general tightening up, etc., and reports to the foreman the extent of heavy repairs needed. He also has direct charge of all service work, such as fuel, oil, lubrication and washing. Tools and accessories are checked, tires are inspected and tested for pressure and brought up to proper pressure if necessary.

The night force frequently is called upon to complete repair work left unfinished by day crew, and is also called on to discharge various duties for the distribution departments, such as switching lights, calling out crews, etc.

The day shop foreman supervises and assists in all general overhaul work, field breakdowns and minor repairs which come into the garage during the day, directing repair and maintenance of batteries, tires and tubes.

One of the superintendent's duties is to see that new trucks are properly equipped for work assigned by installing bodies, cabs, material and tool boxes and accessories; also to authorize and personally direct manufacturing or repair work that is performed by other shops which are especially equipped for that class of work.

The garage repair shop is operated separately, under control of the transportation department, but on account of its proximity to general shops, considerable repair work, necessitating expensive machine-tool equipment and skilled workmen, is executed more economically in general shops, thereby eliminating duplicate capital investment.

The garage should be equipped with the most modern tools and equipment necessary for repair and service work, certain kinds of lathe work, power-operated machine work for grinding, pressing, drilling, brake-lining installations, vulcanizing, spray cleaning, spray painting, grease and oil guns, battery charging, and a complete gasoline and oil service station.

Repair work necessary to automotive equipment is reported in the following manner:

By truck drivers and operators, on operator's daily record.
By inspection of night foreman and service crews.
By supervisor making field inspections.

The foregoing reports, together with statistical cost data of operating expenses, determine the necessity for general overhaul.

The night foreman has access to a systematic inspection and service record of all automotive equipment, which work is performed at stated intervals of time, or record of miles run. He assigns and has executed by the night crew emergency repairs reported. He recommends to day foreman repair work that should be executed by day force.

The day shop foreman arranges to have the heavy repairs made, upon the approval of the superintendent, and other work not performed by the night crews, which can be executed more economically on day shift, portions of which are executed in general shops, especially fitted for that class of repair work.

Instructions to Foremen

Foremen are responsible for the maintenance and efficient operation of all equipment under jurisdiction of the transportation department. Additions or alterations to equipment are not permitted by others, except when authorized by foreman.

Foremen will assign to and supervise the work of all garage employees.

They will inspect all work in progress and will pass on completed work before releasing for service.

Some details of their work, which, being apparently little things in themselves, are often overlooked or neglected, it is desirable to place in print for ready reference, for instance:

On reporting at the beginning of the day's work, repairmen should find the "Daily Shop Card" ready for them, outlining a job on which they may start right in, whether new work or work in progress. (These cards are to be retained on file as a record of the man, as well as of the work he has performed.)

Trouble cars must be kept serviced and always ready for instant use.

The foreman must keep familiar with stocks of extra parts and accessories, keeping enough on hand to save waste of expensive time without tying up too much of investment.

He must make sure that operators and drivers carry on their person the state operator's license card. He should never send a new driver out unless this card has been at least applied for, with official record to prove it.

All garage employees will be held responsible for any damage to company equipment caused by their neglect or carelessness. Foremen will be on the alert to detect such damage, place the blame, and report to the superintendent of transportation promptly.

Drivers and operators must report on "Operator's Daily Record" the amount of mileage enroute and mechanical trouble. Cooperation of the operator with the garage on this point will make things run more easily for all concerned.

Road tire changes should be reported, making sure that the reason for the removal of tires is given on the card so that the clerk can enter it on the tire record card.

Cars which have been assigned to a department for regular work must not be used by foremen or garage employees without first procuring permission of the superintendent of transportation. The only time this rule will not apply is in case of extreme emergency when, no other car being available, plant, line or gas trouble or accident to persons or equipment is of so serious a nature as to warrant immediate action.

No car is to be taken out of the garage by foremen, drivers or garage employees without first notifying office.

No storage or repair work will be done in the garage on employees' cars.

The night garage foreman will be notified by the department head or superintendent of transportation when a car is to be taken out overnight that is not regularly assigned for night work.

Any employee will be allowed to take his car or truck from the garage at any time to use for company business at his regular work.

No private work will be allowed to be done by employees in the garage.

Night, Sunday, and holiday employees on duty will allow no cars to be taken out without orders from the superintendent of transportation, manager, superintendents, or assistant superintendents, except as allowed above. (Any employee will be allowed to take his car or truck from the garage at any time to use for company business at his regular work.)

It is desirable that foremen encourage helpful suggestions from all under them. This means that they shall receive suggestions pleasantly and make a note of them, without regard to their personal opinion of the man or of his suggestion, because, once a suggestion is made to them, it becomes company property, to be used or rejected as the company sees fit.

No persons will be allowed in the garage after regular work hours without permission from proper authority. Garage employees on duty are expected to enforce this rule.

When accidents are reported to foremen, they should take charge, in so far as possible under the circumstances looking after the persons and property injured.

Instructions to Service Men and Washers

Whatever their rating, what is said below applies to all who have anything to do with repairing or cleaning company automobiles and trucks.

Such employees are responsible for loss or damage caused by their neglect or carelessness.

While doing their work, they should keep their eyes open, inspecting while they work, looking out for the smallest mechanical defects of the equipment they are servicing, for instance:

Loose bolts and nuts (rim lugs and nuts).
Missing bolts or nuts.
Loose terminals of head, tail, or spot lights.
Seeing that lights all light and noting their appearance, when lighted, as an indication of condition of bulbs and batteries.
License plates securely fastened.
Keeping nuts and caps on inner-tube valve stems.
Leaks in water-circulating system.
Torn curtains, broken straps, broken curtain windows.
Under-inflation of tires; tires should be tested regularly.

Water should not be left standing around spark plugs, or on parts of autos. Blow off with air and wipe dry.

If enamel on top or bottom sides of fenders, hoods, etc. is broken through and rust has started, touch up with enamel when part is thoroughly dry.

Do a thorough job of lubricating, looking for broken leaves, loose clips, etc. If loose clip is detected, note if it is in proper position on axle before tightening.

Watch for loose spokes in either hub or fellos. Note if brake bands ride properly on drums, whether band-holder clips are bent, or broken off, tension springs set properly, and whether brakes are set evenly for action on both wheels. Note whether brake lining needs renewal.

Be clean in oiling and greasing—don't slop and smear. If grease is running out under brake bands, clean off and see that new felt washers are put in where needed.

Note whether casings and tires are wearing evenly, as an indication of whether wheels are in alignment or that either front axle has been sprung out of true.

When jacked up for servicing, note whether front wheel bearings are exacting adjusted. Wash dirt and grease off tires (grease and oil injures casings).

Head and tail lights must be kept properly adjusted to comply with the law.

See that head, tail and spotlight lenses, reflectors, windshields, curtain glasses, and mirrors are clean.

The company welcomes suggestions which make for efficiency. The foreman will always listen to such from the men.

Auto Operators

The term "Operator" applies to anyone whose duties include the operation of a company automobile for any purpose whatsoever.

Operators are responsible to the garage foremen, as relates to care of autos and will be held responsible for damage caused by their neglect.

They will not operate a company automobile at any time unless they have on their person a state operator's card, or have gone on record officially as having made application for such card.

In the event of a dispute arising as to the use of an auto, the garage foreman has authority to hold the car until the department superintendent arranges for its release.

Before leaving the garage, the operator should look the car over. He should note the condition of tires, whether under-inflated, etc. If operating an emergency car, he should make sure he has a complete kit of tools.

If a puncture or blowout occurs, he should stop the car at once. If only a short distance from garage, he should leave his car and report the trouble to the garage foreman. Under no circumstances should he drive a company car on flat tires—a hundred yards on a flat tire means a ruined tube.

If he is at a distance, he should make the change or repairs himself; if unable to do so, he is asked to telephone to the garage.

All operators will fill out the "trouble card," reporting, in addition to what is required under the other headings, any repairs, tire changes, etc. under the heading "Remarks." They must not fail to report any repairs needed that come under their observation, including punctured spare tubes, slow leaks that require pumping up often, or any faults they may notice in the car or its action while driving. Such detailed information can only be furnished by them; for they, while driving, are in a position to note many little things which would scarcely be discovered by anyone else. Their reports enable the garage force to keep the car in tune, hence their importance.

In case of accident, they shall comply with instructions as outlined on the accident report form.

Changes in transportation equipment assignment are frequently necessary for proper conduct of company business, which changes may sometimes interfere somewhat with the operator's personal comfort. Loyalty to the company is best expressed by making the most of existing conditions and being friendly with the job.

In case of breakdown, the garage should be called direct.

General Instructions to Truck Drivers, Ditcher, Tractor and all Other Operators

Guard carefully by stowing loads well, against loss when under way. Operators are responsible for such loss. See that helpers ride on rear, when necessary to guard load.

Under no circumstances allow sharp bars or pikes to extend over either end of truck, unless protected with a heavy canvas bag having wooden or leather bottom.

Keep truck clean and clear from dirt and waste material in body and material boxes. Material or tools must not project over sides.

The law forbids getting out of gear in descending a hill.

Inspect tires and casings daily, being always on the lookout for cuts, bruises, nails, stones, etc.

Additions to, or changes in, mechanical or accessory equipment are not permitted unless authorized by transportation superintendent.

Operators must know the traffic laws, rules, and ordinances so well that they will, unconsciously, do the right thing at the right time while driving.

If hauling a load which extends more than 12 in. beyond front or rear end of truck, attach a 16-in. red bunting to end of load—at night, a red lantern.

Give the machine on your right the right-of-way at all times. This is the law. Give the other fellow the benefit of any doubt.

If a driver is instructed by his employer to live within the law and he wilfully violates these instructions, he, the driver, and not the employer, is liable.

Under no circumstances drive a company car on flat casings. A hundred yards on a flat casing means a ruined tube. When a puncture or blowout occurs, stop car at once.

Be very careful, if car is equipped with pneumatic casings, when parking at 45-deg. angle not to strike curbing with front, right tire. To do so with any force causes breaks inside the fabric, which pinch the tube and result in blowouts.

Never race your motor.

Do not allow the engine to run while the machine is standing idle.

Unnecessarily quick get-aways, and avoidable quick stops, are very harmful to casings and tires and the mechanical condition of the car.

When for any reason it is impossible to deliver material in the proper place at destination, this must be so stated on the drayman's order, saying why it could not be done, and if a vehicle will be needed.

Note instructions concerning accidents and comply therewith, neglecting no details.

Meetings will be held in the division manager's office following automobile collisions, to complete the report of the accident and to fix responsibility, the meetings to be called by the transportation superintendent.

Carrying of unauthorized passengers is not permitted.

Do not allow more than one passenger in truck cab or on front seat of any truck, if it crowds the driver or in any way obstructs his vision.

Do not allow more than one passenger, in addition to driver, on the front seat of any small roadster or passenger car.

Instructions to Chief Clerk

All negotiations for the purchase of material must be handled in the regular manner, through the purchasing department.

A special shop order shall be issued to cover cost of repairs to automotive equipment damaged in collisions. Record details of accident and fix responsibility.

A special work order shall be issued to cover cost of repairs to privately owned automotive equipment damaged in collision with any owned or rented automotive equipment, as authorized by the claims department. Record details of accident.

Truck drivers and operators assigned for delivery of materials and other special work under jurisdiction of the teaming department must be supplied with written instructions on the drayman's order, showing proper charge account. If work is authorized by telephone order, such work must be confirmed by written drayman's order before the close of the day.

The clerk is responsible to the superintendent for proper accounting of materials carried in material and supplies account in the garage stockroom.

He shall maintain an up-to-date directory of all transportation employees, showing address, telephone number, occupation.

He shall maintain a directory of authorized emergency operators working in other departments, stating types of equipment they are capable of operating.

General Instructions to all Transportation Employees

The garage shall be kept open for business 24 hours daily.

Garage employees on duty Sundays and holidays are expected to do any necessary work; they are not there merely as watchmen.

Should breakdowns require the attention of more than one of the two men on duty at these times, both must not leave the garage. Call out and send another garage employee, if needed.

Work benches must be kept clean and tools and materials stored in their proper places.

Smoking in garage buildings is absolutely prohibited.

All changes in address or telephone numbers must be immediately reported to the chief clerk.

All worn or broken automobile parts must be delivered to the stockroom in exchange for new repair parts. (Stockkeepers will mark on warehouse charge, "old (naming part) returned."

When material is drawn for repairs to division cars, or for repairs to be made on the street, stockkeepers will so mark the stockroom charge and old material will be later accounted for by the garage foreman.

Tags must be placed on casings and tubes showing: date (of removal), car number, odometer reading, cause of failure, and date of exchange, and entries will be made on requisition charge in the same manner as for repair parts. Accessories and tools, if obtainable, must be exchanged for new articles issued as replacements. If not obtainable, the stockkeeper will enter the reason, such as "lost", "stolen", "missing", on the warehouse charge. (The garage clerk will make proper notation on "tool inventory", for that car.)

Material and tools drawn for garage shop use must be exchanged in the same manner as repair parts, or drawn from the stockroom on order issued by the garage foreman.

Any parts or materials wanted, not covered by foregoing rules, will be issued by the stockkeeper only on order of the garage foreman.

The garage foreman will, with the stockkeeper and superintendent, inspect all parts and materials returned and arrange for their final disposition.

It is part of duty of all employees to read all notices on the garage bulletin boards.

Cans of gasoline, on trucks housed in the company garages, are strictly prohibited.

The use of gasoline for cleaning purposes inside any company building is absolutely forbidden.

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*Legislative Report**

This subcommittee made a thorough study of the revised California Vehicle Act of 1931 and prepared a paper covering the provisions affecting motor vehicles in the service of public utilities. This paper was read before the motor vehicle conference. The committee also cooperates very closely with the executives of the state motor vehicle division.

AT the last session of the California State Legislature there was created a committee of five members to be known as the "Automotive Conference Committee" with William B. Hornblower, San Francisco, as chairman, the other members being two senators and two assemblymen.

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* Report by P. H. Ducker, chairman.

The purpose of this committee is to secure data with which to advise the members of the motor vehicle committee of the senate and the assembly at the next session, so that many of the ambiguities and the inconsistencies of the present motor vehicle act will be eliminated.

One meeting has been held in Los Angeles and prior to the convening of the legislature, there will be a number of other meetings.

It is the purpose of this legislative committee to appoint subcommittees for each particular branch or division of motor vehicle operation, such as insurance, taxes, lights, brakes, registration, etc.

Members of the Transportation Section of the P.C.E.A. should notify our chairman of any changes they may have in mind which should be applied to the California Vehicle Act, as it is the intention to clarify the entire act.

With reference to motor trucks, the operators of fleets in the southern part of the state are unanimous in their belief that the intent and the regulations of the present act are satisfactory, and that there should be no particular changes in the different sections applicable to the operation of trucks.

Every member of our Section is urged to give careful study to the activities of the legislative committee and to assist in every way possible.

MAINTENANCE DIVISION REPORT[2]

This committee analyzed repair shop practices and methods of maintenance and general overhaul repairs, field repairs and service work. It made a study of an inspection system, following the preventative maintenance idea. The subject matter was such, however, that it was not believed practical to prepare these papers for publication, although members were furnished copies of papers for their reference.

THE following report covers a few items of automotive maintenance and shows what some of the member companies have reported as being done along this line. It contains some suggestions which have been found to be effective for the various operations.

Checking Blow-by or Lack of Sufficient Compression

One company relies on the compression gage; others note the oil fog in the breather pipe when the motor is running. One company has a volumetric gasometer which is connected to the oil-filler pipe. All other openings in the crankcase are plugged up and the volume of gas passing through the crankcase into the gasometer for a given period of time under given conditions is noted. To operate this, it is necessary to have the vehicle on some type of power-absorbing device, such as a chassis dynamometer. The difficulty with relying on the compression gage is that there is no way of knowing whether the loss of compression is due to slippage past the rings or through the valves. Noting the oil vapor in the oil filler pipe is subject to individual opinion and is not very accurate.

A rough method of determining the slippage past valves or pistons is to put one end of a rubber hose in the crankcase breather and to listen at the other end as the motor is turned over. The hose can also be placed in the exhaust pipe and in the carburetor intake. Although this method is of some value in testing valves, it is not very good for determining the amount of slippage past the pistons, because the oil seal in the pistons is not the same as under running conditions.

One company is considering making an orifice-type meter to be connected to the crankcase breather so that the rate of flow of gas past the pistons through the crankcase will be recorded by the meter. A standard rate for this could be arrived at for a given make of vehicle by comparison with a few vehicles that are known to be in proper condition.

Checking Axles and Spindles for Possible Failure

Axles and spindles usually fail from fatigue. The fatigue usually results in a small crack, which gradually works its way through the entire axle, until the cross-section left is not sufficient to stand the load. Complete failures may often be prevented by inspection of axles to determine whether or not these minute cracks have already started.

To detect these cracks, the common practice is either to strike the axle with a hammer and listen to the ringing noise, or to immerse the axle in gasoline, wipe it dry, strike it with a hammer and see if the gasoline comes out of the crack. The ringing method is not very satisfactory, as it is subject to individual opinion and will not detect small cracks. The gasoline method is more satisfactory and close examination will give satisfactory results.

Another method, which has been tried to some extent and apparently gives good results, has been considered for use by one company. It consists of rubbing printers' ink on the axle, so that the ink will be forced into the cracks, wiping the axle clean on the outside, and covering with gasoline. If the crack is very large, it will immediately show up without any gasoline, as a black line where the ink has penetrated. If the crack is very small, the ink will be seen to discolor the liquid in the neighborhood of the crack when it is placed in the gasoline.

Welding Cylinder Blocks and Renewing Valve Seats

Three of the member companies are replacing cylinder blocks, when they become ruined either by scoring or cracking. One company uses hard solder to fill up the cracks and scores. One company is electrically welding cracks and scores, using a nickel rod with apparently good results. Two companies are repairing worn and scored cylinders with replacement sleeves with good results. In renewing valve seats, two companies are using the replacement seat, screwing it into the block. Two are using the replacement seat pressed in. One company is using the pressed-in seat and electrically welding the seat to the block.

It is not difficult to weld cast iron, but it is difficult to make the weld hold after it is cool. To do it properly with ordinary welding methods, the block should be heated to almost a red heat before welding, and then allowed to cool slowly. This, of course, is impossible on a cylinder block or cylinder head on account of warping. If the metal is welded cold, the part around the weld acts as a chilling agent on the cast iron, which is heated for welding, and forms a layer of white cast iron around the weld. This white cast iron is very brittle, has very little strength, and has a lower coefficient of expansion than the welding material, and when the welding material cools, it contracts and breaks loose from the cast iron. In using nickel instead of steel for welding, it is possible to keep the temperature of the block low enough so that no white cast iron is formed and a successful weld may be obtained. Good results from this type of welding have been obtained with an ordinary a.c. welding set, keeping the voltage and current low, so that excessive heat is not generated.

In putting in replacement seats, either by the screw method or the pressure method, it is possible to get a seat to hold for an indefinite length of time; however, the heat trans-

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[2] C. R. Stanley, Pacific Gas and Electric Company, chairman.
Los Angeles Gas and Electric Corporation: W. J. Schaeffer.
Pacific Gas and Electric Company: F. W. McGuire.
San Diego Consolidated Gas & Electric Company: R. V. Dodge.
Southern California Edison Company Ltd.: E. M. Rondot.

ference from the seat to the block is not very great and seats tend to run hotter than normally. If it were possible to weld electrically or to solder the seat so that there would be molecular contact on all sides, good heat transference would result and the seat would run cool. With electrical welding, it is practically impossible to do this, for the welding material does little more than seal the top of the crack between the seat and the block and assist in holding it in place. It adds very little to the heat conductivity. One company has considered soldering seats by using high-melting-point solder. If this is possible, it should result in better heat conductivity.

Preventive Maintenance Inspection

One company inspects equipment regularly at 60-day intervals, one annually, one weekly, and one maintains no inspection. One company has an organized preventive maintenance inspection which occurs regularly at about every 2,000-mi. run. A printed form is used on which the following items appear:

Engine: Compression
Adjustments
Mounting
Power
Cleanliness

Clutch: Engagement
Clearance
Transmission
Rear axle
Universal joints
Wheels and rims
Brakes
Springs, shackles and radius rods
Shock absorbers
Radiator, pump and hose
Fuel-lines and tank

Lights: Head and spot
Tail and stop
Clearance
Horn
License plates
Certificate (registration)
Fire-extinguisher

Wiring and connections
Battery

Generator (and charging rate)
Starter and gears
Governor and seals
Air cleaner
Oil filter and pressure

Body: Paint
Fenders and splashers
Running boards
Hood and clamps
Top and curtains
Windshield and wipers
Doors and hardware
Upholstery and floor mats
Tire rack
Body bolts

Steering gear (and linkages)

Tire: Spare
Inflation
Alignment

Lubrication (chassis, trans., and diff.)

Tools
Loading

One or more mechanics are detailed to check over the vehicles, noting the items listed on the sheet. Minor repairs, such as adjusting brakes, changing spark plugs, etc., are made by the inspector. Major repairs found necessary, such as loose bearings, leaky radiators, etc. are checked on the sheet and if these repairs must be made immediately, the car is taken out of service. Such items as the inspector cannot repair himself and which are not in need of immediate attention, are repaired as soon as possible. The time necessary to complete the inspection depends largely on the condition of the vehicle and the amount of work the inspector must do. The Model A Ford in fair condition usually takes from ¾ to 1 hr. A vehicle in poor condition may take as long as three hours. It is estimated from experience so far that, when all vehicles have been regularly inspected for some time, the routine inspection will not take more than about ½ to ¾ of an hour.

Cylinder Maintenance—Model T Ford

Some doubt exists as to which of the following procedures is the most economical in the maintenance of cylinders when they become worn so that it is necessary to repair them: regrind, use expander type rings, or purchase new blocks. All of the companies but one are grinding, the period at which grinding is necessary varying from a 40,000-mi. to 20,000-mi. run. From the experience of one company, the following has been considered the proper procedure:

About 10,000-mi. to 12,000-mi. run—new plain rings.
About 18,000-mi. to 20,000-mi. run—some type of expander ring.
About 50,000-mi. to 60,000-mi. run—usually necessary to install new bearings and overhaul motor; new block.

The use of oil filters and air cleaners is undoubtedly a factor in the wearing of cylinder walls. Only one of the companies employs oil filters and two employ air cleaners. Four types of expander rings have been used by one company, as follows: single-piece slotting ring with a radial expander, a three-piece ring utilizing oil pressure for radial expansion, a ring composed of three separate spirals and one single-spiral ring. The first two mentioned have given good results. The third has given poor results and the fourth is apparently giving excellent results but has not been in service long enough to determine this definitely.

TECHNICAL DIVISION REPORT[2]

The work of this division has been to study materials, methods and practices having to do with operation and maintenance of motor vehicles. The following report is based on the experience of members with the several items listed.

Tires—Oversizing

ONE of the members has found it of advantage to oversize tires on the Model-A Ford, using 4.75x21-in. tires in place of 4.50x21-in. and the 5.00x19-in. in place of the 4.75x19-in. on Model-A Fords and other cars using similar size. The additional rubber results in longer tire life, and additional air volume results in better cushioning. In some special cases where vehicles are operated on desert or under similar conditions, special size 5.50x17-in. tires and 5.50x19-in. tires are being used.

Tires—Air Containers

The use of air containers has not been extensive. Some companies are using these, however, under certain conditions where delays due to punctures would be particularly expensive, one company using them to a certain extent on pole dollies, patrol cars and some trucks. So far, there has been no adverse report on the use of these containers.

Tires—Valve Caps

One company has found that the use of a special valve that permits of the inflation of tires without removing the cap is advantageous in maintaining proper inflation pressures, reducing the amount of time for inflating tires considerably and insuring the maintenance of caps on valve-stems. Surveys show that in some garages as high as 75 per cent of the regular valve-caps are missing from valves.

Governors

Two of the companies are using governors on practically all of their light cars. Two others are governing a portion of their fleet of such equipment. Governors of the so-called "velocity type" prevail.

Breaking-in Oil

Most of the member companies are using one form or another of special oil for running in engines when new or after overhauling. One company uses 2½ per cent of transil oil, mixed with the crankcase oil. One of the companies reports using a breaking-in oil containing graphite.

[2] S. B. Shaw, Pacific Gas and Electric Company, chairman.
Los Angeles Gas and Electric Corporation: W. J. Schaeffer.
Pacific Gas and Electric Company: C. R. Stanley.
San Diego Consolidated Gas & Electric Company: R. V. Dodge, Jr.
Southern California Edison Company Ltd.: W. H. Bower, C. O. Hutchins.
The Southern Sierras Power Company: G. E. Gertz.

Fuel—Ethyl Gasoline

In most cases, ethyl gasoline is used to a very limited extent. Two companies reported using it in the larger passenger cars only. One company is experimenting with ethyl gasoline in cars operated in mountain territory. In this case, high-compression heads have been installed on the engines. In cars operating above 3,000 ft. elevation, extra high-compression heads have been installed, capable of giving compression pressures of 90 lb. per sq. in. at that elevation. This has resulted in a considerable increase in power and apparently reduces the amount of maintenance work necessary on these vehicles. In another instance, a small fleet of vehicles operated in valley territory has been operating for several months on a mixture of 50 per cent ethyl gasoline and 50 per cent white gasoline, Grade A. Ignition timing has been adjusted and carburetor jets have been changed to a smaller size, with the expectation that reduced fuel economy will offset the additional cost of the fuel, while the decrease in detonation will reduce the amount of mechanical work necessary on the vehicles. While these tests have not been under way long enough to indicate definite conclusions, there appears to be less trouble from cracking of cylinder heads and blocks than is experienced in other territory where white gasoline is used.

Top Dressing

Several members have obtained good results from the use of top dressing which has cottonseed rubber as a base. Where this has not shown sufficiently rapid drying, dressings based on synthetic resins are being tried with apparent good results.

Floor Cleaner—Treated Floors

A type of floor cleaner which seems to be most satisfactory for treated floors is that using trisodium phosphate or sodium silicate as a base. Cleaners having strong caustic bases result in rapid deterioration of the floor treatment. One member is using the car cleaning solution described below for cleaning treated floors.

Floor Cleaner—Untreated Floors

For cleaning floors that have not been treated, solutions prepared by using any one of several proprietary detergent powders seem to be equally satisfactory. Where there is no floor treatment to be damaged, a relatively active cleaner may be used. Most of the cleaners are composed chiefly of trisodium phosphate.

Floor Treatment

Several types of floor treatments are being used for garage floors. These are intended to keep the oil and grease from permeating the pores of the concrete. The committee as yet is not in a position to make any definite recommendations as to the best type of material to use for such treatment. Materials that are being tried are those using either sodium silicate, iron oxide, or resinous or oil gum as a base.

Crankshaft Oil Reclaimed

The use of reclaimed oil has not been very extensive with the member companies. One company had some tests made recently on oil reclaimed by using several different processes and finds that some of the reclaimed oil corresponds very closely in specifications to new oil of the same brand and S.A.E. number. In one case, there was a reduction in the Conradson carbon content. One company is considering filtration of its oil at some of the larger garages, without, however, attempting to reclaim the oil. Under such a plan, the oil would be drained frequently and filtered, dilution being compensated for by the addition of proper proportions of oil of higher viscosity.

Lubrication of Chassis

One company has standardized the chassis-lubricating practice in its several garages, reducing the number of types of lubricants, other than crankcase lubricating oil to the following six: (1) Transmission and chassis lubricant, used in transmissions, rear axles, winches, shackles, steering gear housings and linkage joints, brake shaft bearings and other chassis parts. For this purpose, a heavy gear oil, containing no soap or filler is used. (2) Hypoid gear lubricant, used in hypoid gear reductions only. A lead-base grease is used for this purpose. (3) Ball and roller bearing lubricant. For the lubrication of all ball and roller bearings, special sodium-base greases designed to resist relatively high temperatures are used. (4) Universal joint lubricant—for universal joints of the oil type, the above mentioned transmission and chassis lubricant is used. It is also used where the joint can be packed with wool. For other types of universal joints, special heavy-duty joint lubricant is used. (5) Water pump lubricant—for water pumps, a special water pump grease having the high resistance to emulsification is used. This grease has a calcium base. (6) Valve and spring lubricant—valve oil, as furnished by the major oil companies, has been standardized on, for use in valve oilers as well as for oiling springs and other points where a penetrating oil is needed.

With approximately six months' experience, this company reports that the above system of lubrication has reduced foaming in transmissions and rear axles, "freezing up" of shackles, and leakage of wheel-bearing grease onto brake drums, to a minimum.

Car Cleaning

Most of the members were not using any soap in connection with their car cleaning. Some were using naptha for removing the grease and traffic scum and polishing with polishes of the wax-free type. One company has gotten good results from a cleaning solution prepared as follows:

Two to four lbs. of neutral soap, such as linseed oil soap, is dissolved in 38 gal. water. Into this solution, 12 gal. distillate is added. The amount of soap required will vary with the hardness of the water, but sufficient should be used to emulsify all of the distillate. This cleaning solution will remove grease and traffic scum, will not streak the surface, and vehicles so cleaned do not ordinarily require polishing. In using this solution, the car is first washed with water and while still wet, the solution is applied sparingly and then rinsed off with clear water.

Pistons

There is apparently a tendency for aluminum-alloy pistons to pick up abrasives, which have the effect of lapping the cylinder walls, thus causing relatively rapid wear of the latter. One of the members is contemplating trial of chromium-plated pistons to reduce this wear.

Spark Plugs

Reports on the recently developed types of wide heat range or universal plugs indicate that they are satisfactory for most of the vehicles operated. In testing plugs and other parts such as pistons, rings, valves, piston pins, etc., one company has adopted the practice of installing parts under test in the same engines with other parts with which comparison is to be made. Thus, a six-cylinder engine may be equipped with two plugs, each of three different makes or types. This results in a more direct test result than where an engine may be equipped with six plugs, all of a kind, for the reason that if all of the plugs are in the same engine, operating conditions to which the different types are subjected are nearly the same. This practice is suggested for the benefit of others who may wish to make comparative tests of such parts.

BUILDING AND POWER TOOLS DIVISION[2]

Developments in the field of devices operated by truck motors and transportable tools individually powered for use in electric utility service have been progressing continually. A few illustrations show recent progress in these lines.

Outfitted for Pole Work

IN Fig. 1 is shown a truck completely outfitted for the digging of holes for poles and the setting of the poles. Behind the wire mesh on the left hand side can be seen an

Fig. 1—Truck outfitted for digging holes for poles and setting poles

air compressor having a free air displacement capacity of 160 cu.ft. per min., which is sufficient to operate two pavement breakers. The compressor is driven by the truck motor.

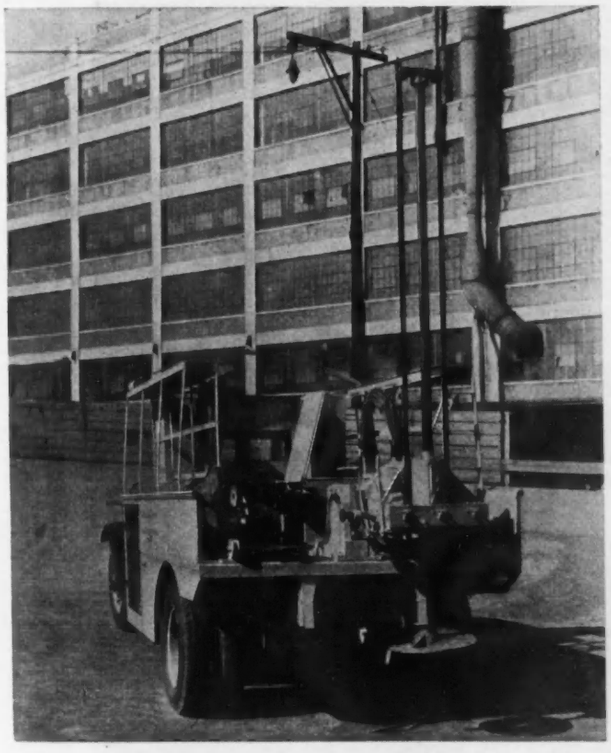


Fig. 2—Augur unit for digging holes

At the rear end of the truck in the next view (Fig. 2), is shown the augur unit for the digging of the holes. The unit is powered from a propeller shaft take-off. The entire digging unit can be lifted off the truck, when it is desired to use the latter for other purposes.

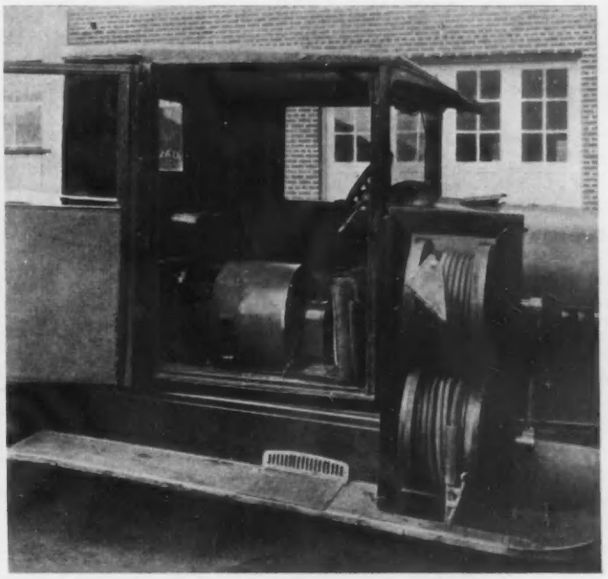


Fig. 3—D.c. generator mounted in cab alongside driver's seat

In the rack at the top edge of the side board, on the left hand side of the truck, are carried the legs of the derrick or crane with which the poles may be set. The wire rope or cable, shown in the rear-end view, wound on the drum of a winch located in back of the cab, can be passed over the sheave at the upper end of the derrick. The design of specialized truck of this character exemplifies the willingness of truck manufacturers and body builders to adapt their products for vocational use.

Arc Welding Outfit

The next photograph (Fig. 3) shows a d.c. generator mounted in the cab alongside the driver's seat. The generator is driven by the truck motor by means of a power take-off. Reactors and other apparatus to adapt the current for arc welding purposes are mounted behind the seat. The positive and negative cables, with ground clamp and electrode

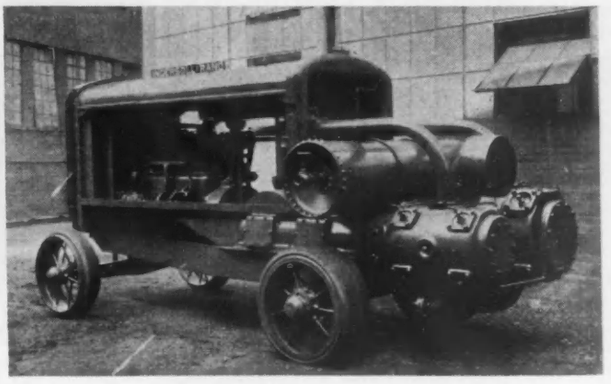


Fig. 4—Compressor outfit

[2] Paper prepared by R. V. Dodge for subcommittee on power devices and power tools. P. H. Ducker, Southern California Edison Company Ltd., chairman.
San Diego Consolidated Gas & Electric Company: R. V. Dodge, C. D. Weiss.

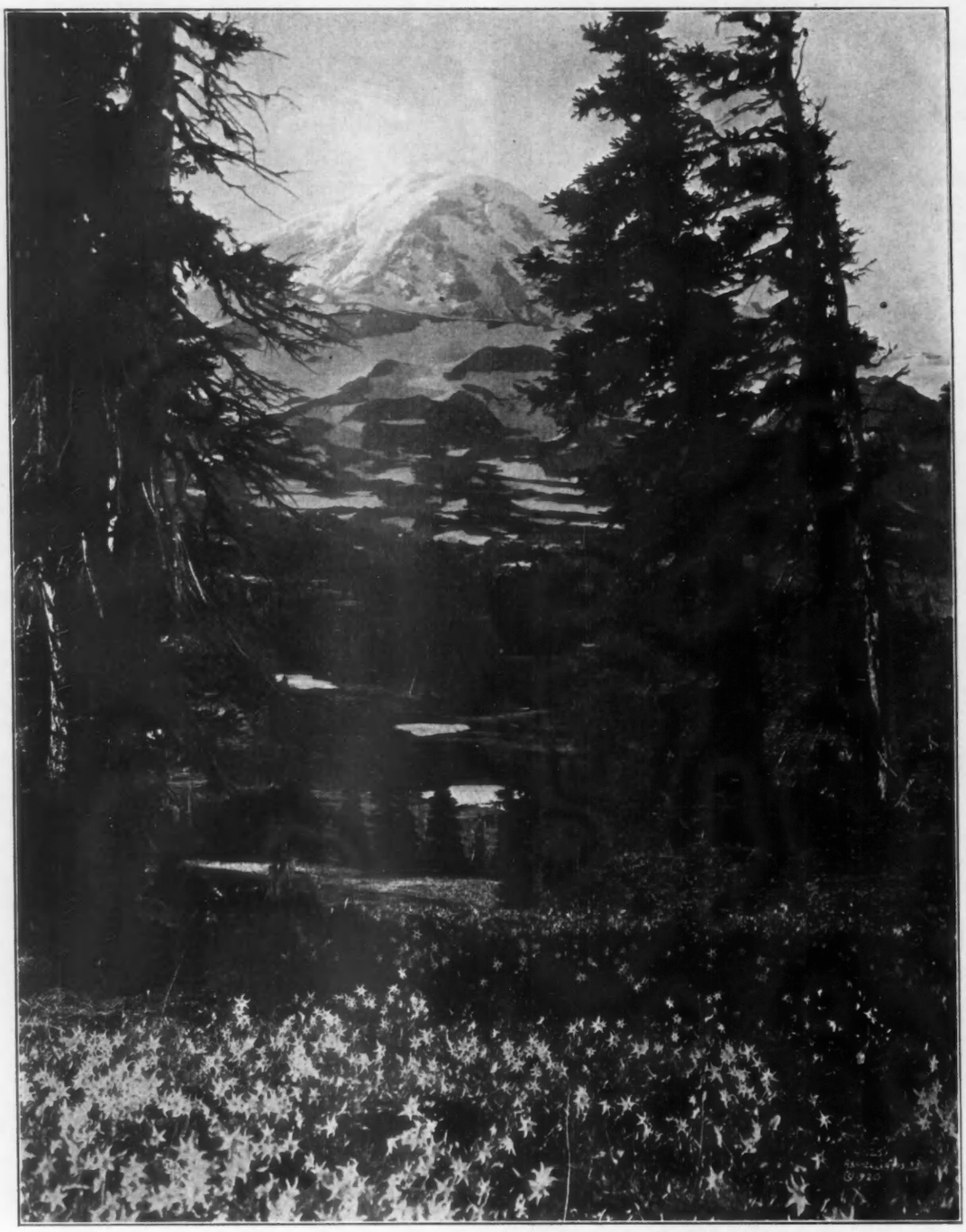
holder, are shown on reels in the frame on the running board.

The generator may also be used to operate floodlights for night work or electric tools of various kinds. The rating for welding is 400 amp.

Large Capacity Portable Air Compressor

The compressor outfit shown in Fig. 4 has a displacement of 500 cu.ft. a minute, and delivers 413 cu.ft. a minute actual. The two-stage compressor cylinders extend over the trailer chassis and are 13-in. and 8½-in. diameters respectively for low and high pressure, with a 10-in. piston stroke. Between cylinders can be seen the cleaner for the intake air. Note that the air discharged from the low-pressure cylinder is piped to an independent radiator, acting as an intercooler, then is led into the high-pressure or second-stage cylinder. The volumetric efficiency for this two-stage compressor is claimed to be 83 per cent against about 70 per cent for single-stage compression.

The gasoline engine is a four-cylinder tractor type, rated at 120 hp., and is connected to the compressor by means of a quickly detachable clutch and silent gear speed reducer. The complete outfit weighs 16,000 lb., and the over-all dimensions are 15 ft. long, by 6 ft. 7½-in. wide by 7 ft. 4 in. high.

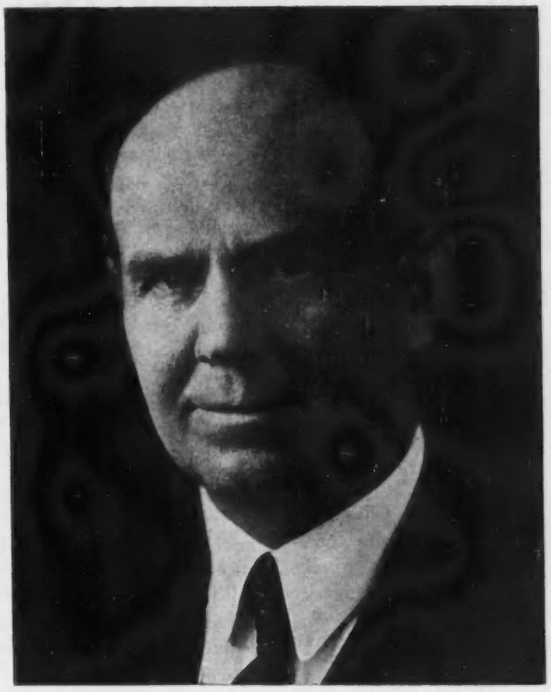


Northwest Committees Meet New Problems in 1931-1932

By P. M. PARRY, President
Northwest Electric Light and Power Association

ANOTHER year of economic conditions designed to try the souls of business men has passed since the last milestone of Association effort has been recorded in these pages. It is fitting to look for a moment at Association activities of the past year to see how these have been made to fit into a changed condition and to meet ever changing problems.

In the first place, it was recognized early in the Association year that member companies would be unable to allot as large an amount as customary for Association expense. On the other hand, it was also recognized that present conditions were creating new problems in utility operation and that, therefore, the need of cooperative study and analysis was in no sense diminished. The officers and executive committee of the Association attacked the problem presented by these facts with a view to finding ways by which the Association could carry on its very necessary analytical and educational endeavors and still keep the cost of this work within the economic limit. A searching analysis of Association operations was made. Some less important activities were materially cut down or dropped and ways were found of financing the more important Association meetings and committee work so as to relieve individual companies of some of the expense they had heretofore been put to in carrying on Association activities. In other words, the principles of sound business management were applied to the management of the Association to attain a maximum efficiency in the relation between results and cost.



P. M. Parry

Some of the results are portrayed in the committee reports published in the following pages, with the exception of the Engineering Section reports which will be published in separate pamphlet form, as formerly. As I look over these reports, I am impressed with the wealth of valuable material they contain. I note with satisfaction the manner in which the section chairmen have shifted the work of their committees to include timely and important subjects. I want to take this opportunity to thank these chairmen, and through them their committee chairmen and committee workers, for producing the character of work represented by these reports, which I am sure will prove profitably useful to every member company.

I want to allude here to the fact that once again the Association executive committee has deemed it desirable to dispense with the annual general convention. This action was taken as one of the economy measures applied to Association operation. While the stimulating effect of a convention on the rank and file of Association membership is fully understood by the executive committee, the cost factors involved were considered to overbalance the value to be derived, and it is felt that all members will understand this action and agree that it was taken for the best interest of all concerned. Let me add, for the benefit of all committee workers, that omitting a convention, at which more or less public acclaim can be accorded to the work done and to the individuals responsible for it, does not mean that this work is not appreciated. As president of the Association, I believe I can speak for company executives throughout this territory, when I say that this work has been appreciated and will be a contribution to the successful conduct of the business in which we are all engaged.

In the absence of a convention, the annual meetings of the three sections customarily holding them take on added importance. From my personal observation of one of these meetings and from the reports of my personal representatives at the other two, I am glad to report that the 1932 meetings of the Accounting, Commercial, and Engineering Sections were fully up to previous standards of these meetings, and in fact, in some respects above former standards. Attendance was on the whole satisfactory and the quality of the papers and discussions presented indicated that the committee chairmen and others had an excellent grasp of the problems that are at the present time vital to our industry.

The accountants at Spokane, April 18-19, took up a number of problems that are currently perplexing accounting departments, and generally followed out their plan of encouraging younger men in the departments to take an interest in and tackle the solution of these problems.

The difficulties besetting commercial departments, brought

about very largely by the status of general economic conditions, are well known to all. In discussing this phase of the business at Portland, February 18-19, the Commercial Section probed deep into the fundamentals of our business, and the committee discussions developed many helpful suggestions for enlisting the support of all outlets in stimulating the public to make a larger economic use of electric service.

Cessation of major expansion and new construction has quite properly focused the attention of engineers on operating problems and a number of these problems, analyzed and reported at the section meeting in Portland, April 13-15, brought to light various facts and ideas that can be converted into increased efficiency in operating our power systems.

As an example of curtailing activity where it seemed apparent that the expenditure of extensive cooperative effort might not be productive of commensurate results, the Public Relations Section minimized its work to a large extent. The section recommended that individual companies concentrate on employee education, and found it possible to carry on its activities through three committees instead of eight. Its reports herein published show progress to date and suggest lines of activity for the future. The women's committee, which continued the excellent work we are accustomed to expect from it, held an enthusiastic meeting in Portland, February 19, at which the activities of the various company committees were discussed, with the accompanying exchange of ideas so mutually beneficial in work of this character.

I write at this length in these pages, because in the absence of a convention no opportunity will present itself for me to address the membership of the Association from the platform. I desire again to commend the reports herein, and those of the Engineering Section to be published separately, to the attention of all company and individual members, and I desire again to thank all the workers who have made these excellent reports possible.

Accounting Section Reports[1]

Introductory Statement

By W. F. MILLER, chairman

IN LINE with a recently adopted plan of rotating midyear meetings, the 1932 meeting was held in Spokane, Wash., April 18 and 19, 1932. Since no general convention has been scheduled for this year, the midyear conference climaxed the activities of the Accounting Section. Although attendance was light, the meeting was an extremely interesting one and great credit belongs to committee chairmen and others for the able preparation and discussions of the many papers presented. All committees reported on studies undertaken, except the budget committee and the statistics committee. Under the able direction of F. W. Brownell, the budget committee prepared a very complete study last year on budget control and, since there have been no assignments from the national committee this year our Northwest committee has not been called upon for any particular activity. Likewise the statistics committee has been inactive because of a lack of worthwhile problems.

The research committee has been active in accumulating tax data and is undertaking a study on collection methods, costs and results. Reports of this committee will be mailed direct to chief executives of member companies. Reports of other committees of the section are published in the following pages.

[1] Executive committee: W. F. Miller, chairman; B. H. Parkinson, vice-chairman; R. H. Jones, F. W. Brownell, A. J. Johnstone, Gus Anderson, G. F. Mackenzie, M. J. Wilkinson, I. E. Joslyn, C. E. Gieseker, W. L. Robbins.

*Interpretation of Some of the Classification of Accounts**

THE work of the classification of accounts committee has, in former years, been devoted to securing the adoption of the National Association of Railway and Utilities Commissioners' classification of accounts, together with the standard form of annual report for electric corporations.

This year we conceived the idea that the scope of the committee's work might be broadened to develop something relating specifically to the classification of accounts. At the Accounting Section executive committee meeting held in Portland in January, 1932, it was proposed that the committee depart somewhat from the routine of past years by presenting topics which might be of general interest. It was decided that a question box concerning accounting problems encountered in connection with the classification of accounts might stimulate interest and be mutually helpful. Armed with this decision, the committee circularized Northwest utility companies for material, and it is this source of information which forms the basis of the discussions contained herein.

The answers to the questions are not to be construed as voicing the opinion of the Accounting Section of the Northwest Electric Light and Power Association, but only of the committee, with which rests full responsibility for these interpretations.

Question—What is proper charge for free service installations to range customers, where the operating company capitalizes cost of installation?

Answer—Most of our companies are striving to increase their system load through sale of electric appliances, the most attractive of which are ranges and water heaters. This question implies that appliances are sold installed without cost to the customer, but where some utilities charge all expense of installing on the load side of the meter to New Business Expense, Account 771.22, Wiring and Appliances, such expense may be capitalized.

The question is quite national in scope, in that it has a very material bearing on load building. At the present time it is a rather live issue with a number of our companies within the Northwest group. A somewhat similar question was submitted in February to the classification of accounts committee, National Section group meeting at St. Louis. It was ruled that where a company makes such an installation at its own expense and retains title to the wires, cable, etc., which it would be obligated to maintain, it would be proper to capitalize the expense of installation by charge to

* A report of the classification of accounts committee, Accounting Section, A. J. Johnstone, Portland General Electric Co., chairman.
Northwestern Electric Co.: William M. Adam.
Portland General Electric Co.: E. I. Snyder.
The Washington Water Power Co.: W. H. Hansen.

Account No. 340, Installations on Consumers' Premises.

Question—Under what circumstances can the replacement of one pole be considered a retirement instead of a maintenance charge?

Answer—In this question, as we review it, the height of the pole remains the same and is replaced with like type.

The test of this problem, it seems to us, lies in the determination of whether or not the pole replaced involves betterment to the property. If the replaced pole results in betterment to the property it is properly capitalizable. It follows that the original cost of the old pole must be retired from fixed capital and charged to depreciation or retirement reserve. If no betterments arise in connection with the replacement, then the expense of substitution becomes a maintenance expense.

Question—When replacing a pole line but using the same wires, which of the following transactions should be used?

(1) Should the costs of the original installation of the poles be written off to replacement, with the costs of the new installation of poles capitalized and the costs of transferring the wires be charged to expense, or (2) should the original costs of stringing the wires be estimated and included in the write-off of the old poles and then the entire new costs capitalized?

Answer—It is our opinion that inasmuch as this problem entails merely the transferring of equipment from the old to the new poles, the property account need not be disturbed except for the transaction relating to poles. Conservative accounting seems to indicate that the cost of transferring wires and equipment should be charged to expense.

Question—When a line is replaced due to highway changes, should the cost be capitalized or carried through maintenance?

Answer—It would appear that the cases are rare indeed when replacing a continuous facility such as a line woud not involve some betterment in the line replaced. For that reason it would seem the most conservative treatment of this problem would be to capitalize the line in its new position and retire the original cost of the old line from fixed capital. The retirement plus cost of retiring, less salvage, should be charged to retirement reserve.

Question—Certain communities are served from a transmission line carrying energy from a company generating plant located at a distance. During rebuilding it becomes necessary to disconnect the line for a considerable period. In order to provide service, it is necessary to purchase energy at a high cost from outside sources. Should the cost of such energy be charged to the construction job? (It is understood that the generating station still operates in order to supply other communities.)

Answer—It is assumed that due to the transmission line shutdown, the station output is materially decreased by reason of the lower demand upon the generating plant. It is also assumed that the energy purchased replaces in kind the deficiency caused by the curtailed demand on the station, and is purchased for resale to existing consumers in order to insure continuity of service.

If these assumptions are correct, the proceeds from the energy resold are reflected in revenue and kw.-hr. sales; then, obviously, the energy purchased should be considered an expense in connection with energy sales. Therefore, the energy purchased is properly chargeable to account 713, Electric Energy Purchased.

We recognize the fact, however, that the cost of energy purchased will undoubtedly exceed the cost of producing this additional energy at the company's own generating station. If this difference in cost could be accurately determined, it might seem logical to charge such difference to the construction job. This procedure could be sustained only on the theory that the increased power cost was due entirely to the rebuilding of the transmission line.

Question—In the case of burned out or otherwise damaged transformers being replaced, should the expense of rewinding, which is a major job of repair, or repairs of any other nature, be charged to maintenance or should the expense of replacing and repairing be handled through replacement reserve?

Answer—The property account has not been affected by rewinding the transformer, since upon purchase the transformer is charged to fixed capital and is carried at original cost until permanently removed from service.

It is not an unusual practice to charge expense in connection with repairing burned out transformers to the replacement reserve on the theory that the expenditure has prolonged the life of the transformer. The expense of rewinding is a major item of expense and may be classified as an extraordinary repair, because it may run to 50 per cent of the original transformer cost. Ordinary repairs are charged to expense. Again, for reasons that are obvious, many utilities will charge this cost of repairing and replacing burned out and damaged transformers to maintenance expense, and are justified in so doing.

Question—How is interest during construction computed and what basis is used?

Answer—There are several methods that may be applied in determining interest applicable to construction, each of which has its staunch supporters, but the burden of proof for each, after all, rests with the utility to justify the method used and rate of interest charged.

A rather common practice is to accrue interest on all construction expenditures of $1,000 or over, with a construction period minimum of thirty days, based on an interest rate of six per cent per annum of 360 days.

Interest is computed, the first month, on one half of the total expenditures for the number of days construction has been in progress.

During the following months, interest is calculated on the total expenditures to the beginning of the month, plus one half the current month's expenditures, for the number of days construction work has been in progress for that month.

EXAMPLE

(Jan. 11-Mar. 21, 1931)

Construction Period	Expenditures	Amount Subject to Interest	Days	Int. at 6%
Jan. 11 to 31, 1931	$ 9,500	½—$ 4,750	20	$ 15.83
Feb. 1 to 28, 1931	12,500	½— 6,250		
Plus bal. at beg. of month	....	9,500		
		15,750	28	73.50
Mar. 1 to 21, 1931	8,500	½— 4,250		
Plus bal. at beg. of month	....	22,000		
		26,250	21	91.87
Total interest during construction				$181.20

Question—What method is used in apportioning salaries of division managers?

Answer—It has been argued that local and division managers exercise the same functions in their districts

and divisions as do the officers of the company, because their jurisdiction extends over all the property represented in their districts and that, therefore, these salaries should be classified as administrative salaries and charged to Account 781.11.

Since the text to Account 781.11, Administrative Salaries, contains the broad statement, "whose jurisdiction extends to the entire system and whose services cannot be allocated to the several departments," it is doubtful if we will be in agreement in this regard, because of the diversity of conditions under which we operate.

Obviously there are situations which warrant refinements in the distribution of salaries and expenses, justifying apportionments to each operating group of expenses, or from transmission to general expenses, inclusive. Such allocation should not be an arbitrary general office assignment, made purely for the purpose of getting into each operating group a uniform part of the manager's salary, but should be based upon experience. Each local manager will be able to estimate, with a reasonable degree of accuracy, the time devoted to each phase of the utility operations, and this estimate should prevail in distributing his salary. The basis should be revised as occasion demands. Where it is not possible for the local manager to make reasonable assumptions as to distribution of his time, departmental daily time tickets are advisable.

Question—To what accounts should office supplies used in local and division offices be charged?

Answer—It is inferred that this question applies to items of expense common to both commercial and general expenses, the distribution of which is contingent upon the organization set-up.

Where a utility classifies its local or division managers as executives, with jurisdiction over the entire property embraced in their respective territories, expenses relating to administration are properly chargeable to the several classifications within the administrative group of expenses.

Expenses incurred for and relating to the commercial department are properly chargeable to that department. Since but one account within the commercial group is designed to take care of supplies and expenses, all other accounts being entirely labor, it is not an uncommon practice to break down Account 761.4, Miscellaneous Supplies and Expenses, between the labor accounts to which they relate, either by adding to the title of the labor account "including supplies and expenses," or by adding a subaccount for supplies and expenses under each labor account. For illustration: "Account 761.1, Commercial General Labor, Including Supplies and Expenses" or "Account 761.12, Commercial General Supplies and Expenses." The expenses so distributed are, for purposes of reporting to the regulatory bodies, reclassified to Account 761.4, Miscellaneous Supplies and Expenses.

All expenses should be specifically applied departmentally.

Question—Should merchandise costs be based on an increment cost basis, or an actual cost of prorata expenses, including promotional expense, administrative expense, rent, lights, etc.?

Answer—Actual merchandise costs cannot be accurately ascertained under any method because of the close relationship existing between merchandising operations and other utility operations.

Generally speaking, we are in the appliance business only for the purpose of increasing the sale of electric energy. To attempt to burden appliance sales with theoretical and arbitrary apportionments does not, in our opinion, serve any useful purpose. After all, it is the expenses which would be eliminated if merchandise operations were divorced from those of the utility we are most interested in. Certainly it would be unfortunate, from the utility standpoint, if expenses formerly charged to merchandising stepped up the utility operating expenses.

Your committee is, therefore, of the opinion that an increment cost basis is preferable.

Question—Is it proper to record earnings of subsidiary companies in the accounts of the parent company?

Answer—From the standpoint of consolidation and having available in one place surplus available for dividends, such practice is ideal and has the sanction of eminent accounting authorities. In cases involving minority interests, only such portion of the subsidiary companies' earnings as are applicable to the capital stock owned by the parent company is taken into account.

The usual method is to take up monthly the net earnings of subsidiary companies by charge to "Earnings Receivable from Subsidiary Companies" under "Investments in Affiliated Companies" and credit to "Undistributed Earnings of Subsidiary Companies" under "Surplus." When dividends are received from subsidiary companies, they are credited to "Interest and Dividend Revenue." A reversing entry is then made for the dividend received by charge to "Undistributed Earnings of Subsidiary Companies" and credit to "Earnings Receivable from Subsidiary Companies."

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*Centralized versus Decentralized Billing, Accounting and Collection**

By J. F. TERRY

BILLING with either the stub or register sheet plan of customers' accounting is gradually replacing the combination bill and ledger plan among the larger electric utilities of the country. These changes offer to such companies an opportunity to centralize their billing and, while it is argued by some companies operating in small towns and communities that the advantage of ledger records of customer accounts produced locally outweigh the economies of a centralized system, it is generally conceded that the trend is toward centralized billing. Both the stub and register sheet plan are extremely flexible, there being many ways of accomplishing the desired results in connection with customers' billing.

Since centralized billing offers greater economies than local billing, this paper will discuss principally the procedure of a centralized billing plan.

For utilities having all of their customers located within one thickly settled district or city, it is practical to have all the accounting work centralized in one office in which all billing and credit posting is performed.

Utilities having their customers scattered over a large territory, including perhaps many cities, towns and villages may centralize all the billing, if the transportation facilities are sufficiently adequate to enable prompt movement of meter-reading records and bills. It is advisable in this case to have all accounting and

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* A report of the customers' records committee, Accounting Section, Gus Anderson, Utah Power & Light Co., chairman.
Idaho Power Co.: Allen Ashton.
The Montana Power Co.: T. L. Doran.
Northwestern Electric Co.: F. L. Nagle.
Pacific Power & Light Co.: R. W. Lawlor.
Puget Sound Power & Light Co.: A. R. Weidermann.
The Washington Water Power Co.: J. F. Terry.

collection work, except preparation of the bill, performed by the district office and a daily report made to the central office of total debits and credits, enabling the maintaining of a proper control.

It is advisable from a collection standpoint to issue one bill to a customer, showing all of his charges, such as light, power, flat, water, merchandise, arrears, etc. There are two satisfactory methods that may be used to get merchandise and arrears on the customer's bill: (1) by the district office adding these items to the bills on receiving them from the central office, (2) by passing these items to the central office for billing through the meter book especially designed for this purpose.

Customers' bills may be delivered by regular collectors, mailed or delivered by high school boys after school hours. If either of the latter two plans is used, it is advisable, in the case of large utilities, to provide places conveniently located for the payment of bills by those not desiring to mail checks.

It is very important that great care be exercised in designing forms, in order that economical operations may be obtained and at the same time produce the results desired by the utilities.

The chief economies of centralized billing are due to the high degree of efficiency which may be obtained in large units by having experts employed on each section of the work.

Following is a brief outline, covering the main points for efficient centralized billing:

Meter books should be designed to care for all the necessary billing data, and of a size that permits easy mailing.

Each district office should be numbered, each meter reading book within a district office should be numbered and each service location within a meter book should be numbered, as: District 12, Route 23 and Customer 340.

All customer records in both the central and district offices should be maintained in this numerical order. Index to customer accounts should be maintained in alphabetical order.

Meter-reading dates should be fixed for each district office to permit continuous billing and eliminate a peak at the central office.

All changes of folios, names, addresses and billing data should be reported to the addressograph department at the central office on a form especially designed for this. These changes should be mailed to the central office in advance of the meter books to be billed, so that the bills will be in line with the accounts.

Meter readings and demands should be checked for high or low readings by the district office and meter books should be held at least one day by the district office to permit checking of readings and entering skips.

Special and final readings are rendered by the district office. A copy of all such bills should be inserted in the meter book in front of the meter index slip for that customer. The central office takes up as revenue all such bills, at the time of billing the meter book.

After the routes are completed by the billing operator, they are turned over to a clerk for proof of billing and finally classified as to number of customers, kw.-hr. and revenue, under such headings as are required by the utility. Then the completed routes, bills and proof or register sheets are mailed to their respective districts for collection.

A transmission phone system as maintained by some utility companies is an essential thing in centralized billing, as many difficulties arise during the course of billing which can be straightened out without passing any accounts.

Centralized billing, as compared with decentralized billing, can be made more efficient and economical to utilities having adequate transportation, if the proper system and forms are applied and if such system is properly supervised.

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*Quarterly or Bimonthly versus Monthly Billing**

By R. W. LAWLOR

IN DETERMINING the advantages and disadvantages of quarterly or bimonthly billing over monthly billing, the utility should consider as important factors: the size of the town affected, the nature of its population, whether permanent or transient; and the size of the average customer's residential bill, which will depend largely on whether the utility sells several different kinds of service, such as electricity, gas, water, and merchandise.

Quarterly or bimonthly billing appears more practical for residential customers than for commercial customers. The amount of a two or three months' commercial bill presents a more serious collection problem, and the amount of money tied up in commercial accounts billed for periods longer than a month is an important factor. Also, most commercial customers like to receive their bills monthly for their accounting records. The bimonthly or quarterly billing plan, therefore, generally applies to residential customers within a given area, but does include certain smaller commercial customers which are in that area.

There are numerous advantages in quarterly or bimonthly billing over monthly billing. A direct saving is made in reading meters and delivering bills once in two months instead of once each month, and in collectors working an account once in two months instead of once a month. A substantial saving is made in bookkeeping help, billing help, addressograph help, cashiers, and the cost of bills. The advantages are greater in towns enjoying a permanent instead of a transient population, and where the average residential bill is a normal one and not subjected to high seasonal bills for several months of the year due to house heating or other seasonal service used.

Some of the disadvantages from quarterly or bimonthly billing can easily be seen in collections, sales campaigns, and contacts with customers. When billings are made for a two months' or greater period, some customers have already discontinued service and cannot readily be located, which would result in greater losses from uncollectible accounts, the amount depending on whether or not deposits are required by the utility. This practice sometimes causes the new tenant to have an opening bill rendered which covers a four-month's period of service. The effect on merchandise sales campaigns would also be noticeable, as the mailing of circulars and pamphlets with the customers' bills would be reduced by half. Meter readers' and bill deliverers' contacts with customers, and customers' contact with employees through payment of bills would also be reduced one-half. It is also felt that, even though the bill comes to the customer only once in two months, the amount of the bill, being necessarily twice that of

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* A report of the customers' records committee, Accounting Section.

a single month's bill, tends to create more high-bill complaints and to cause the customer to retrench on the use of energy and appliances.

Our company operates in a number of fairly small towns and renders bills monthly. One town is dependent on the lumber industry for its chief support; its population is more or less transient, and, with frequent mill shutdowns, collections become an important factor, and the billings for over a month are not desirable. We also operate in a seashore vacation resort where the business is seasonal and where the population is highly transient. Here again it is not desirable to bill for a period longer than a month. In fact a number of the customers are billed on a weekly basis.

Without a doubt there is a very apparent saving effected in quarterly or bimonthly billing, through clerical help, printing and stationery, etc., but it is a question whether this saving is great enough to offset the disadvantages arising from more uncollectible accounts, less contact with customers through advertising circulars and personal contact of employees, high-bill complaints, etc.—a large part of which is intangible and difficult to value.

*Methods Used in Obtaining Meter Readings After Meter Reader Fails to Get Readings on First Call**

By Allen Ashton

FAILURE to get a reading of the customer's meter is, of course, due to only one cause—inaccessibility of the metering installation. Meters located in such places as bathrooms, kitchens, back porches, basements and furnace rooms are a common occurrence, especially in the older homes or commercial buildings. In such cases, if the family is away from home and leaves the doors locked, or if the particular room in which the meter is located in a commercial building is locked, a reading cannot be obtained by the meter reader.

One company, in an effort to get a meter reading each month from all customers, has used two methods. First, a dial card is left so that the customer can mark the position of the hands and either bring or mail the card to the respective office or billing point. If this method fail, and especially if a reading has not been obtained for some time, an order is given to the customer's repair department, who make a call during their regular runs and attempt to get a reading. In very large communities, however, this method is expensive and must be avoided if meter reading costs are to kept at a minimum. No attempt is made to send out for readings on rural meters, except through the regular trips of the meter reader or by use of the dial post card, as it would be impracticable. In many cases the meter reader has been supplied with duplicate keys to certain buildings, which permit him to enter such building to read the meter.

The rules and regulations of most companies call for meters to be "installed in a convenient location," and I believe it would be possible from a legal standpoint to insist that all meters be located so that readings can be easily obtained every month. However, if a wholesale attempt were made to stand on our rights in this respect, it would disturb harmonious relations with a large number of customers. There are other ways to improve this situation.

A survey by meter readers on one property listed meter locations in which readings were particularly hard to get. Some of these meters were located so that the reader had to obtain a ladder or climb on top of a porch or shed to read them. Others were in sheds or rooms which were always locked. Representatives of the company approached customers having the most troublesome installations and asked them to have certain wiring changes made which would permit moving the meter to a more accessible position, offering at the same time to bear a portion of the cost. In nearly all cases the customer was agreeable and in this way a number of bad meter locations were improved. The value of this plan hinges on two points: first, the number of such troublesome meter locations, and, second, the expenses involved as compared with revenue received. However, an extra call each month or the slowing-down of the meter reader are an added expense which must be considered.

It is also worth while for the electric utility to keep in contact with the contractor dealers in their respective territories, so that with their cooperation the location of meter loops will be such that readings may be easily obtained.

From the foregoing, I believe that to eliminate those cases where it is difficult to obtain meter readings on first call, the following steps are necessary:

1. Approach customer to have wiring changes made.
2. Cooperation of wiring contractors.
3. Use of dial postcards.

It would seem that follow-up calls to obtain readings should be discontinued entirely in scattered residential or rural districts, except in cases where no reading has been obtained the previous month. It is, of course, very desirable that a reading of each meter be obtained each month, but not to the extent of a second personal call. Minimum or estimated bills can safely be used in most cases to bridge the gap until a reading is obtained, when adjustment of the bill can be effected.

A survey of the inaccessible meter locations by the electric utility would seem to be a practical step. Then, a definite policy could be followed to eliminate these by asking the customer to change his wiring set-up so as to place the meters in a more convenient location, even to the extent of offering some financial assistance. In old or new buildings where new wiring is being installed, the utility should take steps to see that the meter is placed in an easily readable location, preferably on the outside of the building and not over 7 ft. high.

* A report of the customers' records committee, Accounting Section.

*Joint Ownership in Poles**

By G. F. Mackenzie

THE principle of the joint use of poles by two or more utilities operating in the same territory is so well established that it needs no brief as to its propriety. There is, however, a divergence of opinion

* A report of the fixed capital committee, Accounting Section, G. F. Mackenzie, Pacific Power & Light Co., chairman.
Idaho Power Co.: E. T. Montgomery.
Northwestern Electric Co.: William M. Adam.
Portland General Electric Co.: A. H. Morris.
Puget Sound Power & Light Co.: Giles Hunter, Jr.
The Washington Water Power Co.: C. E. Gieseker.

in the matter of ownership of such poles, one school of thought advocating joint ownership and another advocating individual ownership.

Individual Ownership

Individual ownership necessitates periodic rental charges for space occupied by other utilities and has the advantage of undivided title to all poles erected by the utility. It obviates the necessity of charges to other utilities for maintenance and replacement of poles and in practically all accounting features produces a clearer and simpler record than in the case of joint ownership. The question of liability may be satisfactorily arranged in the rental agreement. It is believed that the amount of work necessary to account for pole contacts on a rental basis would be considerably less expensive than the necessary accounting in connection with joint-ownership transactions. If the number of jointly owned poles constitutes a small percentage of the total number of poles owned by a utility, serious consideration should be given to the subject before a joint-use agreement is effected with neighbor companies. It is natural that utilities should desire their fixed capital to contain the value of all of their plant and equipment used in the operation of their business and thus reduce rentals to a minimum, but it is believed that under some conditions rental charges are more to be desired than voluminous and troublesome fixed capital records. If it were possible to have each of two or more utilities, operating under a joint-use agreement, own the same number of poles, so that rental revenues would offset rental charges, then the rental plan would undoubtedly be satisfactory to everyone interested.

Joint Ownership

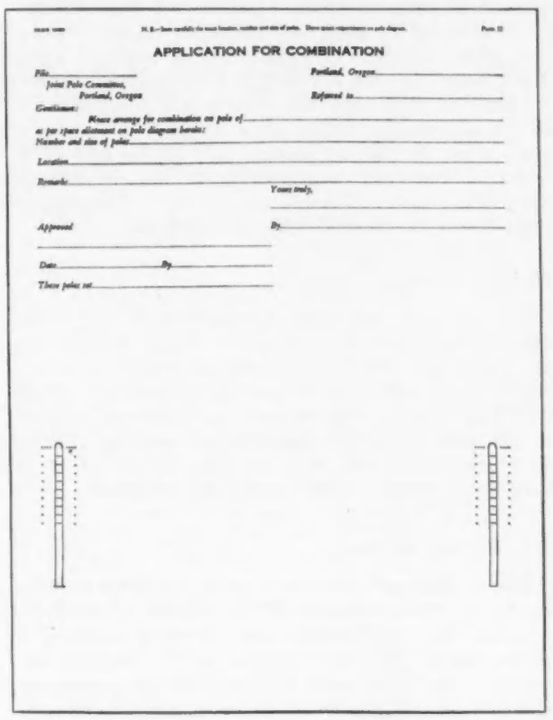
The condition just cited is practically unattainable, and utilities are, therefore, driven to the troublesome problem of joint ownership. The problem is troublesome, possibly only because it involves a multitude of accounting entries, both physical and financial, and demands continuous care to insure the proper distribution of all costs in connection with the jointly owned property. If each transaction be followed logically and carefully, no greater amount of difficulty should be experienced than in accounting for any other class of fixed capital.

Joint-Pole Committee—

When a joint-ownership agreement has been effected, a joint-pole committee should be established, composed of one member from each of the utilities which have become parties to the agreement. This committee should have the responsibility of settling all questions relative to the joint use of poles, and should have adequate accounting advice regarding the establishment of the necessary routine. The joint-ownership agreement executed by the proper officials of the interested companies, should provide the necessary authority for the committee to enable it to function properly. If the number of joint-ownership transactions is sufficiently numerous, the committee should operate an office apart from any of the utilities interested, where all joint-ownership records may be properly taken care of and where original documents are filed and available at all times to any of the parties to the agreement. The cost of operating such an office should be prorated monthly to the member companies on the basis of number of transactions handled. Such costs should, of course, be capitalized.

Minor Utilities Interested—

Subsidiary to the joint-ownership agreement there should be another agreement between the interested utilities and what might be called the "minor companies" whose business necessitates a small number of pole contacts. This group would consist of telegraph companies, messenger companies, watchman-service companies, steam and electric railroads, etc. Joint own-


APPLICATION FOR COMBINATION

File..... Portland, Oregon.....

Joint Pole Committee,
Portland, Oregon Referred to.....

Gentlemen: Please arrange for combination on pole of.....

as per space allotment on pole diagram hereto:

Number and size of pole.....

Location.....

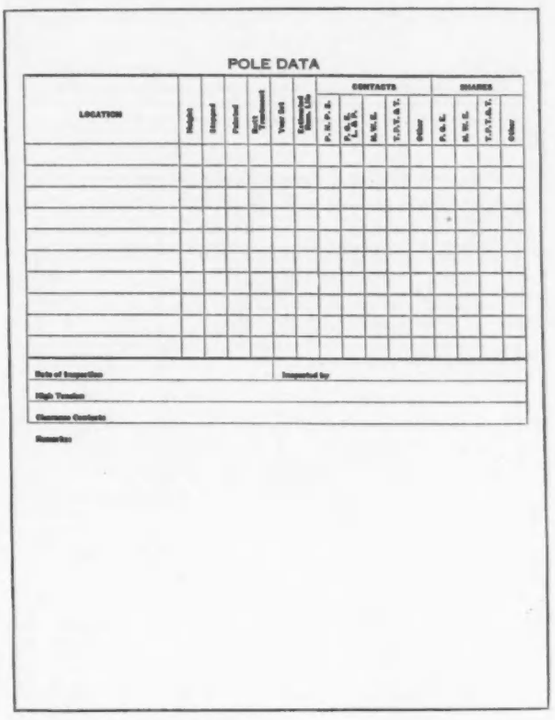
Remarks.....

Yours truly,

Approved By.....

Date..... By.....

These poles set.....


POLE DATA

LOCATION	Height	Grouped	Painted	Rigid Tightened	Year Set	Reinforced Where Set	CONTACTS P. H. P. & L.	CONTACTS P. & T. & L.	CONTACTS W. U. C.	CONTACTS T. P. T. & T.	CONTACTS Other	SHARES P. & L.	SHARES W. U. C.	SHARES T. P. T. & T.	SHARES Other

Date of Inspection Inspected by

High Tension

Clearance Contacts

Remarks

Fig. 1—Front and back of application blank

ership should be extended to this group, but no representation should be permitted on the committee. Costs of handling minor company transactions in the committee office should be billed monthly by the committee at a fixed price per transaction, and the supplementary agreement should provide for the adherence of such minor companies to the rules and regulations prescribed by the committee.

Accounting Routine—

The routine described here is that which has been used for a period of eighteen years by a group composed of one telephone and two electric utilities as "major" parties to the agreement, and six minor parties. During that time no major difficulties have arisen and the committee is now operating under the original agreement.

Application—

When one of the subscribing utilities wishes to place equipment on a pole not owned by itself, an "application for combination" (see Fig. 1) is filled out in quadruplicate, signed by the proper authority (generally the line superintendent), and the first three copies are sent to the joint-pole committee's office. The joint-pole secretary keeps one copy and forwards the other two copies to the owning company named in the application. The owning company approves one copy and returns it to the applicant via the joint-pole office. This provides the applicant with authority to make the desired contact.

Supplement—

The joint-pole secretary then prepares a "supplement" (see Fig. 2) which shows all information necessary for the physical and financial records of the transaction, such as the location, equipment to be attached, space necessary, description of pole, life of pole, and the share and value to be sold by the owner to the applicant.

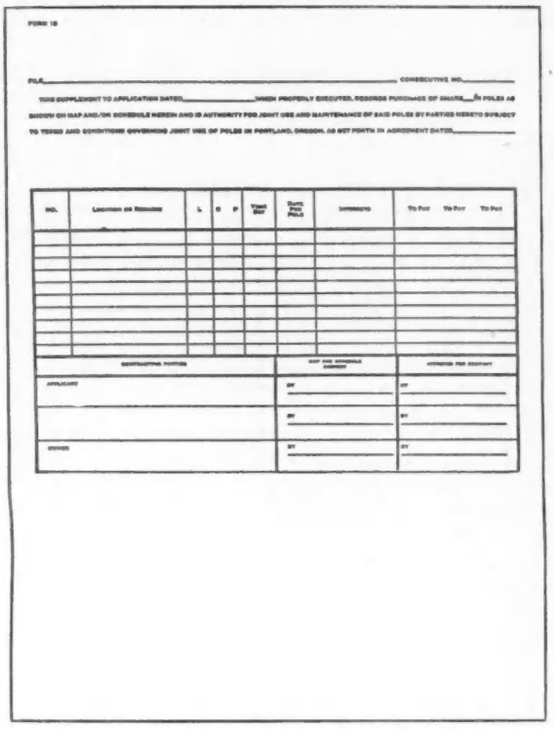


Fig. 2—Supplementary form filled out by secretary

Signatures to this document are obtained from the contracting parties by the committee secretary and the supplement then becomes a permanent record of the joint-pole committee. When completed, a sufficient number of blue-prints are made by the committee office and distributed to the interested parties, for billing and fixed capital records. The billing is done direct by the owning company to the applicant, the transaction being complete so far as the committee office is concerned when the signatures are affixed to the supplement and the blue prints have been distributed.

Supplements are filed by number, one number relating to a specific location. Subsequent changes in pole ownership at a particular location are recorded on supplements bearing the original number, suffixed with a letter. A cross index by locations is maintained by the joint-pole secretary.

Shares—

Interest in poles are bought and sold on the basis of "shares," a share being a percentage of the value of a pole, fixed by the committee, in relation to the number of contacts desired, and the size of the pole.

Prices—

Interests in poles are bought and sold on the depreciated value of the pole at the time of the transaction. For convenience, the committee has established a schedule of standard prices by years, for all sizes and conditions of poles, to which the depreciation is applied on a straight-line basis.

Title to Jointly Owned Poles—

Some question has been raised as to the validity of title to jointly owned poles purchased in this manner, but it is pointed out that the original agreement, properly executed, the supplement describing the property purchased, and the voucher passed for payment, provide certainly as good title as exists in purchases of any other material or equipment. A piece of equipment bought on an ordinary invoice carries no more evidence of title than the invoice and the possession of the equipment. These also exist in the purchase of joint poles. So far as passing title on the sale of interest is concerned, it is considered that the original agreement, the supplement and the regular established procedure again furnish sufficient authority.

Maintenance—

The joint-pole committee concerns itself only in the sale and purchase of interest in poles. Attachments are placed on poles by the interested utility, and all maintenance and operation arising from the use of the joint-pole are either performed by individual utilities, or the costs thereof become charges between utilities. Such items arise from the transfer or moving of equipment necessitated by some operating condition.

Pole Replacements—

The replacement of poles involves a charge to fixed capital and the retirement of the original value of the old pole. For this reason, pole replacements have to be handled in the same manner as the original sale and purchase of interest, necessitating the completion of a new supplement form, a transaction involving the records of the joint-pole committee, on account of the

change in percentage of value owned, resulting from the apportioning of the cost of a new pole as compared with the cost of a depreciated pole.

Fixed Capital Records—

Charges for the purchase of interest in joint poles should be accounted for in the same manner as any other charges to line extensions. There seems to be no good reason why any exception should be made in their case. If a job-order system is used, certainly the cost of the interest in the pole should be included in the cost of the job, otherwise an allowance will have to be made in figuring the relationship of investment to revenue returns. By the same token, the credit for interests sold should be included in job-order costs. Sufficient records can be made by the engineering department on maps and by a maintained file of joint pole transactions, as reflected by their copies of supplements, to insure complete control of the joint-pole situation. The bulk of records necessary in connection with joint-ownership poles are more physical than financial.

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*Internal Auditing**

THE Accounting National Section appointed a specific committee to report on internal auditing. This committee has divided the work up among the various geographic divisions. The following balance-sheet accounts have been assigned to the Northwest Section.

Accounts Receivable—Customers.
Accounts Receivable—Contract Sales.
Accounts Receivable Interest and Dividends and Capital Stock, Outstanding.

At the meeting of the executive committee of the Accounting Section, it was agreed that this assignment would constitute the work of the general records committee for this year.

Introduction

Inasmuch as it has been realized that an audit by a professional firm cannot hope to determine all the minor errors which will exist in the books of a company having thousands of retail customers, the matter of internal auditing becomes a vital necessity. The average "audit," which is now completed annually for the various public utility companies, usually comprises only a balance sheet audit, and the company submitting such an audit to its clients usually refers to its work as an "examination" rather than an "audit." This is done to indicate that it has not in detail verified every transaction which has occurred during the preceding year, but has examined the major accounts, and verified the scheme of procedure which has resulted in the closing balance sheet. It is, therefore, obvious that some good system of internal auditing should be in force at all times. Such a system would result in greater confidence in the accounting department on the part of both the management of the company and the firm of professional auditors who will take care of the annual examination. Such an internal audit may be classified in two sections, which, though separate, are closely allied, i.e., a system of internal check by members of the force, and local audits by a special staff working for and controlled by the general office. The main functions of the system of internal check are, of course, to prevent clerical errors, and if necessary, collusion between members for the purpose of fraud. The special function of the local audit is to verify the results of certain business in the local office, and to obtain consistency in the records throughout the various offices. The general thought of consistency cannot be too much stressed. While it is impossible, and impracticable, for all electric companies to adopt the same system of accounts and accounting, yet whatever system is adopted by any one company should be closely followed throughout their local offices.

Accounts Receivable—Customers

Office Routine—

The existing office routine for "Accounts Receivable —Customers" should be carefully studied by the auditor, in order to familiarize himself with the company's policies and procedure, and to determine in which phases of the work error or fraud is most likely to occur.

Applications for Service—

The auditor should examine all applications for service to see that they have been properly signed by the person or representative of the person desiring service, and otherwise executed in accordance with the existing office routine.

Connect Orders—

Connect and disconnect orders should be examined to see that they are properly issued and permanently filed. Completed connect orders should be checked by the auditor to determine if any are missing, and if so, the corresponding number in the book of duplicates should be looked up and the necessary steps taken to locate the original or ascertain if work has been completed. The auditor should also check the entry of meter constants on connect orders to see that they have been properly recorded by the bookkeeper.

Meter Constants—

The verification of meter constants is a matter which should receive much attention. Where the older-type meters are in use, the verification of these constants is a simple matter, since a list of meters owned should show the type of meter having a constant. However, where it is the practice to use a standard 5-amp. meter with a small transformer, in place of the large regular constant meter, the verification of meter constants becomes a more difficult matter. A periodic check of such meters having a constant should be made by the meter department, and a list prepared, which should then be verified through the meter book onto the bills. It is necessary that a periodic check of these constants be made, since it is quite possible for these constants to be changed, if load is added by some individual customer.

Cash Receipts—

The amount of cash receipts should be verified with the bank deposits, both with the passbook, and, if necessary, with the statement personally secured from the bank. This amount should be verified with the cash received as shown in the cash book, and any sundry or miscellaneous amounts strictly examined for distribution.

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* A report of the general records committee, Accounting Section, M. J. Wilkinson, Pacific Power & Light Co., chairman.
Mountain States Power Co.: Jack Ford.
Northwestern Electric Co.: N. H. Stephens.
Pacific Power & Light Co.: E. C. Winslow.

Allowances and Adjustments—

The auditor should verify that all allowances and adjustments are correct, and are made for a legitimate reason. He should further see that they bear the full necessary signatures for approval.

Verification of Amounts Billed—

While it is impossible for the auditor to examine personally every individual account, yet we feel that all large power accounts should be verified and refigured, the account being traced back through the various steps to prove the meter constant, and the rate schedule. Test checks should be made of regular billing of domestic service to verify the extensions. A list of flat-rate installations should be prepared by the auditor, and these should be submitted to a periodic verification.

Delinquent Accounts—

The auditor should verify the delinquent balances by a check on the total billing, and the total cash, less any allowances or adjustments. The delinquent accounts receivable should be listed and aged by the auditor, according to the number of months delinquent. These should be verified with the amount of delinquents added to the bills, and should be discussed with the person having charge of collections.

Collections—

A carefully worded letter or printed verification notice, stating that this information is for audit purposes only, usually brings a good response from delinquent accounts, and is a valuable check both on the billing, and the accuracy and the trustworthiness of the employees. When discussing these delinquent accounts with the collection department, the auditor should verify that the proper collection notices are being sent to the customer, and that these are being followed up by the collectors. This should be particularly noted in the case of accounts long delinquent.

Employees' Accounts—

The auditor should verify all employees' accounts, to ascertain that they are being billed at the correct rate. If it is the policy of the company, he should see that delinquent employees' accounts are speedily paid, and, if necessary, should authorize or secure authorization for a payroll deduction.

Uncollectible Accounts—

After an account has been ascertained to be worthless, and all means of collection have failed, the auditor should verify that it has been properly charged off to the reserve for uncollectible accounts. In this case, again, the auditor should see that the write-off of uncollectible accounts bears the necessary signatures of authorization. He should also see that the customer who incurred this obligation is no longer on service, or, if so, he should verify the reason for this write-off to bad debts.

Personnel—

The auditor's report should include remarks on the neatness, carelessness, or competence of the persons in charge of the records. In making these remarks, the auditor should state his reasons for these remarks, and his suggestions for their betterment. In order to obtain more efficiency, he might suggest rearrangement of the work or a reallotment of the different individuals to various tasks.

Control—

The control for "Accounts Receivable—Customers" should be verified and checked to see that it is in agreement with the general ledger records.

Accounts Receivable—Contract Sales

Sales Agreements—

The auditor should ascertain that sales agreements are executed for all installment sales. He should also verify the filing of conditional sales contracts in the public records, in accordance with the laws of the state in which the company operates. The original amounts and terms of sales agreements should also be verified.

Appliances on Loan—

It is important that the auditor verify that appliances loaned have been properly recorded, since this privilege is very often abused and also often accounts for inventory discrepancies. A schedule should be prepared, covering all appliances on loan.

Sales Orders—

The auditor should verify that sales orders are correctly recorded. If sales orders are issued in numerical sequence, they should be checked to determine if any are missing, and, if so, the reason therefor.

Control—

The control for "Accounts Receivable—Contract Sales" should be verified and checked to see if it is in agreement with the general ledger records.

Verification Notices—

Outstanding balances should be verified by obtaining from the customers, statements in which they admit their liability to the company. This is a valuable check on the accuracy and trustworthiness of the employees, and, also, usually brings a good response from delinquent accounts.

General—

The procedure for auditing cash receipts, allowances and adjustments, delinquent accounts, collections, and employees' accounts, under "Accounts Receivable—Contract Sales," is identical with the procedure for the corresponding accounts under "Accounts Receivable—Customers."

Capital Stock—Outstanding

To verify the outstanding capital stock, the auditor must examine the stock registers or ledgers and the stock certificate books. These records should then be compared with the lists of stockholders. Where the corporation maintains a transfer office, or if some other organization acts as transfer agent, the auditor should obtain a certificate from the transfer agent as to the capital stock outstanding. The minute books should be examined and the authorized capital stock verified with the accounting records. The auditor's balance sheet should show the entire authorized capital stock (sub-

divided into classes, if there be more than one class), the amount unissued, and the amount that may remain in the treasury of the company.

The shares of treasury stock, or reacquired stock, if any, must be examined by the auditor; the certificates should be counted and examined as to proper indorsements, if any, or for any other irregularities.

It is not sufficient for the auditor merely to schedule the outstanding capital stock; he must also assure himself that all stock issued has been fully paid for in either cash or property. He should also examine into the status of any issued stock or any stock subscriptions which have not been fully paid and should obtain from the subscribers, certificates in which they admit their liability to the company.

Any arrears which may exist with respect to accumulated dividends should be computed by the auditor as a memorandum, but should not be recorded on the books, as no actual liability exists for dividends until they are declared.

Accounts Receivable—Interest and Dividends

Interest Receivable—

The auditor should examine the asset accounts of the company to determine which accounts bear interest. He should verify interest accruals and see that all interest accrued has been properly recorded. When interest accrued has not been recorded, the auditor should determine the reason therefor, by a discussion of such items with the proper official of the company.

A carefully worded letter or printed verification notice should be mailed covering all outstanding balances, which serves not only as an effective means of collecting overdue accounts, but also provides a proof that cash receipts have been properly recorded.

Dividends Receivable—

The auditor should prepare a schedule of stocks owned by the company and compute the dividends accrued thereon. He should see if all dividends declared have been properly charged to dividends receivable. If dividends have not been regularly paid, the auditor should verify that such dividends have not been declared.

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*The Problem of the Small Storeroom**

THE personnel of this year's committee was made up from the companies operating in the eastern part of the Association territory, with the underlying thought that much of the value of its work would come from free discussion among its members and their direct contacts, opportunity for which, due to general conditions, did not seem very promising, were the representation to be more widely distributed.

One meeting of the committee was held at Pocatello, Idaho, attended by all members except one, and with each of the participating companies represented. Discussion centered about the problems of the small storeroom and the ideas expressed at that time and those subsequently developed through correspondence have been collected in the accompanying paper. This does not presume to cite treatment by a particular utility, nor to outline forms or methods, but seeks rather to bring to the surface a subject worthy of some attention and one which does not seem to have been touched upon in any recent committee activity.

Growth of Small Offices

Activities of our utilities in the later period of their development have brought about the linking up of many communities, large and small, into networks of service facilities. Following the interconnection of individual companies' distribution plants, has come the tying together of unrelated systems, and more recently there has been rapid extension of electric service lines into rural districts. All of this, with the steady improvement in service standards and the development of an increasing number of electric devices and uses, has necessitated the establishment and maintenance of service offices in a great many small communities. Often, for a given utility these materially outnumber the offices in more populous centers.

Need for Stocks

Organizations in these small offices vary in size, depending on the character and extent of the territory covered and on the policies of the particular utility with reference to small construction, merchandising and accounting. Perhaps seldom does a single employee take entire care of the company's business; more frequently the personnel consists of from two or three to six or eight individuals. In any case, the needs of service and the general practice of energetic merchandising require the carrying of a certain amount of maintenance materials and supplies, perhaps some construction materials, and inevitably some stock of a variety of current-consuming devices, major and minor, with ordinary accessories and repair parts. At offices of this nature, the investment in such stocks commonly runs into a few thousands of dollars, at least, but with such a limited total and volume in movement as to preclude the necessity or economy of full-time employment of a man for handling and recording.

Importance of Control

Our thought has been particularly directed to a consideration of the problems which surround the carrying of, and the accounting for, the materials, supplies and merchandise at these smaller storerooms (as, for convenience, we may term them), where special attendance is not warranted. No attempt at a comprehensive study of the situation has been made, as affecting the various organizations in our Northwest Division, but it can safely be accepted as fact that the total value of stores distributed among these smaller storerooms, particularly for those utilities with widespread operations in thinly populatted sections, forms a considerable part of the "materials and supplies" asset in this territory. Further, it is found, in some cases at least, that the rate of turnover is lower, this being affected in some measure by the relative part of the merchandise investment needed for display. Or it may be held down, in some circumstances, by the material kept in reserve for emergency uses.

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* A report of the purchasing and storeroom committee, Accounting Section, I. E. Joslyn, Idaho Power Co., chairman.
Idaho Power Co.: A. W. Ashton, L. W. Brainard.
Montana Power Co.: George Woodhouse.
Utah Power & Light Co.: J. A. Bullock, A. D. Smith.
The Washington Water Power Co.: R. D. Williams.

Nature of Quarters and Use of Space

Local office occupancy is usually on the basis of lease, the accommodations for the larger portion of stores being included in the quarters so provided. Attention is properly given to the securing of offices in locations convenient to the general public and in districts about which retail trade centers. Since the stores department is a perpetual support of those front lines, the sales and service departments, this may well include some consideration for the space available for stock, its extent, location and convenience. Direct and ready egress to street or alley is desirable, and basement quarters, particularly for heavy articles, are to be avoided as much as possible. Too much space may be a disadvantage, in its encouragement for carrying excessive quantities, retention of useless articles and because it is extra room for which to care.

To serve efficiently, large storerooms must give attention to orderly and logical arrangement of their stocks, and will usually be found to have evolved standards for shelves, bins and racks. The small storeroom naturally presents a much lesser problem of this type, but it is often found that ready and rapid inspection of stores is hampered by the failure to devote specific space to their accommodation. Mingling of stores articles, records, advertising matter and display material, empty cartons, office cleaning tools and supplies, line tools, customer-owned appliances accepted for storage, resale or repair, clothing and personal possessions, workbench tools and supplies, etc., is easy and common. It might be better, were space allotted for each class of article, as no more room is required, but, in any case, definite separation of stores from other supplies, tools and records should be arranged and maintained.

Storage Facilities

As has been intimated, larger storerooms have reached some standards for storing the less bulky articles, a definite recognition of the value of order. It is equally desirable, though not actually necessary, to follow that plan in the small storerooms. For, in addition to its effect on order, with its everyday convenience and economy, as well as at times of inventory or check, the establishment of a general standard for shelving and bins makes for better and somewhat more inexpensively constructed facilities, tends toward uniformity on a given property and, as a whole, produces a more pleasing and satisfactory result. Wood is, of course, the material used for most of such construction, but for small appliance repair parts and resale supplies, steel shelf units, available in different styles and manufactures and with movable partitions and drawer sections, are found to conserve space and, for the accommodations provided, to be less costly and more durable. And in the event of removal to new quarters, which takes place occasionally and almost naturally, due to the practice of occupying small office locations under lease, the existence of approved standards and the use of portable units proves advantageous.

Maintenance of Stocks

In a common plan of organization, the small office is one of several such, which are subsidiary to a larger and central office having jurisdiction over territory which forms a convenient operating unit. Direction of local stores rests in the same central office, at which point some extra and fuller stock is carried, both for its own use and to protect the immediate requirements of the junior offices. For the replenishment of stocks, the local manager is the author of requisitions, though his control, by this means, of the character and size of his stores may from time to time receive interference from the concentration of construction or maintenance material for special work directed from the outside, or by the supplying of initial allotments of newly accepted lines of merchandise or models of appliances or quantities for special sales campaigns. Such requisitions call for approval by the supervising office, to assure that standard articles are being obtained and that quantities are suitable. Delivery follows from the central point, or shipment is secured from the dealer through regular purchasing procedure, dependent on the extent of the central stock, the required date of delivery and the economy which may come from either direct shipment by the jobber or the practice of quantity purchase by the control point.

Recording Movement

Due to the many and varied activities, nearly as extended for the small office as for the larger one, specialization of work by the members of the force cannot be practiced more than in part. By reason of this, hardly an individual is constantly on duty at the office or storeroom, and delegation of full responsibility for the accounting for stores is hard to make. Attention to the checking and recording of receipts may, with reasonable success, be assigned to one employee, but the handling of issues is apt to become a common affair. Since that which is everybody's business tends to degenerate into nobody's business, there is need for special attention to the training of all who may have access to stores, and this generally includes all employees, so that they may make a practice of making appropriate records of their own withdrawals at the time articles are taken, although a charge for the exercise of general oversight may be given to a particular person.

Desirability of Centralized Accounting

At the small points, the employment of clerical help, on account of the limited value placed on such service, frequently resolves itself into a local matter. While the talent available in the small community may have great possibilities, it is usually inexperienced in utility accounting necessities and practices. Training takes time and its value is largely lost when employment changes occur. Or if the keeping of stores ledgers devolves upon one whose work is largely on the outside, it is apt to produce indifferent results and at a sacrifice of time which might better be used elsewhere. From the standpoint of good results, then, more easily and inexpensively secured, there is much advantage in the centralization of the work of keeping ledgers and preparing reports at the larger, or control, office, leaving for the local small point only the preparation of the essential records of receipts and issuances.

Excess and Slow-Moving Articles

While the volume of business handled through a single small storeroom is relatively inconsiderable, some excess or slow-moving or non-standard stock is found to accumulate with the passage of time. Some items of line material beyond ordinary needs come from the leftovers from extension work, and other articles are salvage from reconstruction or maintenance work, some of the latter being of a type no longer accepted as standard. Old or substandard material deserves prompt and careful inspection, so that, by early and complete elimination, the expense of further handling

or storage of that which may be declared obsolete is saved. That acceptable for further use should receive only conservative valuation, and good practice requires the return of it to service at the earliest opportunity, so that its full worth may be realized and stocks kept clean and fresh.

Of merchandise surplus, this may arise from failure to gage correctly, either on the occasion of special campaigns or otherwise, the public acceptance or the organization's ability to place. Accessories and repair parts, sometimes, are acquired and lie unused, from the failure to realize that equipment models change and that an existing recurrent call may presently become an infrequent one, or from the mistake of accumulating a small stock of some parts on the basis of a single occasion of need. For the small storeroom such repair stocks should be carefully limited, and dependence should be placed on the central point to supply infrequently called-for items. Depreciated merchandise, too, forms part of the problem, in view of the unavoidability of some repossessions and the practice of accepting trade-ins. Many of these appliances need some repair or attention before being fit for reoffering, and it should be recognized that, while it is easy to put them aside, space is unprofitably taken up and the investment in them is frozen until operating condition and attractive appearance have been restored to make possible their disposal. A similar loss applies in the case of the appliance which has been robbed to meet some service necessary, when there is failure to place immediate order for the missing part or to replace it promptly on receipt.

Control by Centralized Accounting

Keeping of ledgers at the supervising office, to which should be daily dispatched copies of all records covering that day's transactions, furnishes control of a kind which should largely obviate overstocking. Presence of excess quantities are readily apparent, as is that of articles which have failed to move. Supplementing this control, periodical visits by the storekeeper, or other individual charged with the general responsibility for stores, serve to keep a check on stocks, their order and the kind of attention given to the accounting for their movement. And these visits make the occasions for effecting arangements for removal of any excess and slow-moving items, for discard of that which is obsolete, and for directing the disposal of junk. Necessary adjustments in the ledger records should be made not less frequently than once a year, based on complete and supervised inventories.

Emergency Materials Storerooms

A variation of the small storeroom we have been considering, is the depot or cache, entirely separate from and uncontrolled by a commercial office, established along transmission lines for the purpose of having repair materials convenient for emergency use. Such deposits have their justification in the saving obtained, when they are located at places where easy and relatively inexpensive transportation is possible and in the limitation of interruption periods, due to their adjacence. Accounting for such materials as used is apt to be somewhat difficult, as long periods may elapse without use and stores control is remote and indirect. Being subject to theft, destruction, deterioration and obsolescence, there is much merit in the position that the maintenance account may properly be charged at the time the materials are placed. Otherwise, reliance must be had in periodical checks to provide a basis for more gradual assimilation into operating expenses. With the betterment of transportation facilities, including the relocation and improvement of highways, some such stores locations are likely to disappear naturally, from elimination or consolidation.

Simplicity of Forms

There is variation of details in the practice of different organizations in recording the movement of stores, but the methods of handling will not be materially different whether the storeroom is small or lar In either case, a minimum of simple forms is the goal, more desirable and more easily reached, perhaps, for the smaller points. Certain fundamentals are usually provided for by the use of several different forms. these being:

Request for articles to be supplied.
Report of receipt of such articles.
Report of movement of stores from one stores location to another.
Record of materials and supplies withdrawn from stock for use.
Record of the return of unused or of salvaged materials.

Common to all of the transactions reflected is the necessity for the listing of the articles handled. Otherwise there is need only for showing what is to be done, is being done, or has been done, with them, all of which may be accomplished successfully with the provision of a single suitably designed form to be used variously as transactions take place. This makes a substantial reduction in forms to be kept at hand for use and is an economy in printing. Use of such a common-purpose form for recording sales to customers is not desirable, but it is readily employable as a merchandise delivery order and for the suspense record of merchandise out on approval or for demonstration.

Conclusion

The individual small unattended storeroom is recognized as a small problem, but the problem is much enhanced in size by the existence of a considerable number, or a predominance, of storerooms of this nature on a property. As such storerooms are indispensible adjuncts of the electric utility and lack constant direct attention, these requisites are offered in summary, for their successful and economical conduct:

1. Small but adequate quarters, conveniently located and with standard storage facilities, with definite and complete separation of stocks from the many tools, records and supplies of the office.
2. Restriction of merchandise stocks to only a small reserve beyond display needs, and judicious limitation of repairs carried.
3. Installation of the idea of the necessity for recording transactions immediately upon their taking place.
4. Location of control records at a central office in the operating territory.
5. Constant attention to the disposition of excess, used or substandard materials and merchandise.
6. Personal visits and supervision by the storekeeper.
7. Minimum number and simplicity of forms.

Commercial Section Reports*

Introductory Statement

By GLENN L. JACKSON, chairman

THE work of the bureaus and committees of the Commercial Section was in the main completed at the annual section meeting held in Portland, Feb. 18-20, 1932. At this meeting reports and discussions were heard from four bureaus and twelve committees on all phases of commercial activities. Most of the reports discussed at that meeting are published in the following pages, but a few, for one reason or another not published, should be here referred to, in order to present a complete picture of Commercial Section activity during the past year.

REFRIGERATION BUREAU

The refrigeration bureau is again organized with a regional director for the Northwest and directors for each state to tie in with and coordinate the national refrigeration campaign in this territory. The personnel of the bureau is as follows:

Regional Director—George M. Gadsby, Utah Power & Light Co., Salt Lake City.

State Directors—

Idaho—L. W. Brainard, Idaho Power Co., Boise.
Montana—J. C. Ryan, The Montana Power Co., Butte.
Oregon—Glenn L. Jackson, The California Oregon Power Co., Medford.
Utah—H. M. Ferguson, Utah Power & Light Co., Salt Lake City.
Washington—V. H. Moon, Pacific Power & Light Co., Portland.

At the Portland meeting, Mr. Gadsby outlined the activities of the second year of the campaign and pointed to many ways in which local communities could cash-in on this national effort.

LOAD BUILDING

In addition to the reports of the committees of the merchandising bureau herein published, three other subjects pertaining to this phase of commercial development were heard at the Portland meeting of the section. Dean H. S. Rogers of the School of Engineering, Oregon State College, Corvallis, discussed the part that might be played by universities and colleges in commercial development through research, invention and testing. He defined the difference between these three activities, indicating the most satisfactory way of carrying on each of them by making the most efficient use of facilities and personnel available in the territory. Papers dealing with load building in Oklahoma and Kansas by A. A. Brown, sales manager, Oklahoma Gas & Electric Co., and William H. Hodge, vice-president, Byllesby Engineering & Management Corp., were summarized, and these brought out some of the uneconomic conditions created in those states by the anti-utility merchandising laws recently effective there. The value of a merchandising department to a utility company, approached from an accounting standpoint, was a subject of considerable interest presented by H. O. Hussong, The California Oregon Power Co., Medford.

It should be added that the theme of the meeting seemed to center around a rather general desire on the part of the utility companies to improve dealer relations and to develop the market for electrical utilization devices through all possible channels. A number of representatives of manufacturers and distributors of electric appliances in the Northwest territory were present at some of the sessions as were a number of retail dealers operating in Portland. It is felt that, from the discussions on the floor of the meeting, a better mutual understanding of the many factors involved in the distribution of appliances to the public was acquired by all groups.

Departing somewhat from the procedure in former years, a display of electric ranges and refrigerators was held at the same time and place of the meeting. Manufacturers and distributors of every make of electric range and refrigerator offered for sale in the Portland area were invited to participate in this display, and a large majority of them took this opportunity to exhibit the latest model of their respective products.

The following reports are commended to the attention of commercial men as containing many valuable suggestions for the satisfactory development of load and the sale of kilowatt-hours.

* Executive committee: Glenn L. Jackson, chairman; L. W. Brainard, vice-chairman. L. B. Gawan, R. B. McElroy, B. P. Baily.

LIGHTING BUREAU[1]

Introductory Statement

By L. B. GAWAN, chairman

IN ADDITION to the four committees of the lighting bureau, the bureau was organized by states with a chairman for each state as follows:

Idaho: Orland C. Mayer, Idaho Power Co.
Oregon: T. W. Fitch, Portland General Electric Co.
Utah: George L. Ellerbeck, Electrical League of Utah.
Washington: Ladner V. Ross, The Washington Water Power Co.

These chairmen have been collecting data pertaining to developing the lighting business in their respective states. These data were summarized at the annual Commercial Section meeting in Portland in February, but inasmuch as they were then and are now incomplete in some respects, they will not be published at this time. These reports will be made available to the new chairman of the lighting bureau at the beginning of the next association year.

Reports of the committees of the bureau follow.

[1] L. B. Gawan, Utah Power & Light Co., chairman. H. C. McDaniel, Pacific Power & Light Co., vice-chairman.

*Outdoor Lighting**

EACH year a committee is appointed to analyze and report on outdoor lighting, which covers street and highway lighting and floodlighting. For the past

* Report of the outdoor lighting committee, lighting bureau, Commercial Section. H. C. McDaniel, Pacific Power & Light Co., chairman.
General Electric Co.: George Barker.
Northwestern Electric Co.: M. S. Glenn.
Pacific Power & Light Co.: G. B. Bocarde.
Westinghouse Electric & Manufacturing Co.: George Boyd.

five years, special analyses have been made and rather definite recommendations submitted. These analyses have covered the economic and sociological value of street and highway lighting to the public, the commercial value to the central station company, the value as an aid to traffic control, and as an accident deterrent.

We refer particularly to the reports during the last five years because in these reports an earnest effort has been made to find a method of increasing the kilowatt-hour sales for this class of service. The reports of this committee for 1927, 1928 and 1929 formed a group of three connected reports and undertook to survey the field of application, to establish a definite classification, and finally to make a more or less definite recommendation for an organization within the central station company for building up this load. These three reports have definitely developed the fact that street and highway lighting is an economic and social necessity and that it is a desirable load for the central station. The report of 1931 was of a more general nature than the four preceding reports, but distinctly emphasized them and reiterated the desirability of the load to the central station.

Yet the development of street and highway lighting has not kept pace with the development of the appliance and so-called commercial load. In fact, in spite of these reports with their definite recommendations and the generally admitted values, this field has been more sluggish in its response to the urge of modern conditions and requirements than other fields served by the central station industry, indicating unmistakably that there is something radically wrong. What is it?

The analyses made by your committee suggest that the sales promotional methods are:

(a) Inadequate and lacking in force.
(b) Incorrect in technique and application, or totally lacking.

Sales Promotional Effort Inadequate

Before we proceed to the reiteration of our recommendations in the 1930 report and to offer new suggestions for selling street and highway lighting service, it will be profitable to survey the causes of the inadequacy of the sales promotional effort. The most obvious causes are:

(a) Lack of definite allocation of responsibility for street and highway lighting promotional effort within the central station organization.
(b) An unfounded but nevertheless general notion that this class of central station service is not merchandisable.
(c) Lack of definite and equitable financing programs.
(d) Lack of a real appreciation of the characteristics of the load and its value as a producer of income.
(e) In many cases, inequitable and uneconomic rates.
(f) Lack of initiative on the part of the central station in giving serious consideration to committee reports and lack of effort to put recommendations into force.

Your committee asks you the following questions:

(1) What has been done to place in operation any of the methods suggested and recommended in the 1930 report?
(2) What has been done to effect legislation in any state in which our association operates, to provide the necessary machinery and funds for planning, installing, operating and maintaining highway lighting systems?

Judging by the advancement made during the last five years, the obvious answer is nothing, or practically nothing.

Those street lighting systems which have been installed, with few exceptions, have been the result of promotional effort from sources outside the central station organization. Public utility companies have established commercial departments to sell kilowatt-hours for various kinds of service, but with a few notable exceptions, none of the efforts of these departments have been directed to the sale of kilowatt-hours for street and highway lighting. This class of service can, we believe, be developed and sold by aggressive sales effort, just like any other service which the central station has to offer.

Central station companies, in order to get additional revenue from this source, must realize:

(1) That street and highway lighting is a commodity, which can be sold like any other commodity.
(2) That an adequate and effective street lighting system induces higher intensity lighting in store windows and interiors and more and better street lighting in contiguous and related communities, which, in turn, starts another cycle of complementary lighting.
(3) That modern conditions require for the public interest, street illumination many times greater than present values.
(4) That present traffic density and speeds on main interurban highways, and those which we may reasonably assume from the present trend, will be encountered tomorrow, demand fixed and permanent illumination of a high level, and that they must realize that they must organize for effective merchandising of this service.

The 1930 report of this committee recommends a fairly definite procedure for such organization, and we in this report reiterate those recommendations. In that report, your committee also recommended that a committee be appointed to secure legislation affecting highway lighting. No such committee has ever, to our knowledge, been appointed, nor has any effort been made to secure such legislation, officially sponsored by the association.

There can be no highway lighting systems even planned, much less installed, until the proper legal processes are established. This can only be done by the legislatures in the different states, and such legislation is not going to be automatic. We submit with this report a copy of legislative bill No. 437, introduced by the judiciary committee of the house of delegates of the State of Maryland, at the legislative session, March 17, 1931, which may serve as a guide to similar legislation in this district.

We again recommend that a committee be appointed to secure similar legislation in the states in which this association operates, or that some already existing permanent committee be charged with this responsibility.

At the risk of some repetition, we submit the following suggestions for the effective merchandising of street and highway service.

1. Organize for the effective merchandising of street and highway lighting service

(a) By making the commercial department responsible for the sale of street and highway lighting service.
(b) By building up within the commercial department a lighting service division equipped to render up-to-date service on street and highway lighting problems.
(c) By selling the advantages of street lighting load and its incidental value as a good will builder to all central station employees, and by continually keeping the subject of street lighting before them.
(d) By thoroughly surveying the possibility for street and highway lighting development in detail for each community served. This survey should include the determination of the individuals in each community who combine the ability for civic leadership and an unselfish interest in civic advancement. Such individuals need not necessarily be in public office. Suggested form for analyzing your street and highway lighting load possibilities is attached to this report.

2. Assume leadership in promoting adequate street lighting.

(a) By demonstrating the desirability of each community adopting a competently engineered and definitely planned and budgeted ultimate and progressive street lighting plan. Such a plan should definitely establish all the characteristics by way of classification and zoning of an adequate street lighting service, due regard being given to satisfactory appearance at a reasonable cost.
(b) By keeping the subject of good street and highway lighting before civic groups, Chambers of Commerce and other similar local organizations.
(c) By selling the advantages of good street and highway lighting to the newspapers and keeping them informed on the subject.
(d) By advertising the economic and social value of good street lighting in newspapers.
(e) By the design and use of appropriate window displays,

exhibits and signs. Keep the subject of adequate street lighting before the public.

(f) By compiling data showing the effect of good street lighting in local communities and elsewhere.

Further suggestions for promoting good street and highway lighting are as follows:

Provide every district sales manager and district manager and each salesman in the commercial department with a simple summary of the street lighting code recommended by the Illuminating Engineering Society. Inasmuch as the central stations are being faced with the possible curtailment of municipal expenditure for street lighting, your committee urges that the timely article entitled "The Cost of Reducing Street Lighting," appearing in the January, 1932, issue of the N.E.L.A. Bulletin on page 29 be carefully read.

Encourage cities to light with suitable highway luminaires, those sections of main highways lying within corporate limits, which in many cases coincide partly or wholly with urban main traffic arteries.

Organize to secure highway lighting legislation.

Survey existing pole lines between cities, towns and villages to determine availability of suitable mountings for highway units.

By way of emphasizing the commercial value of the street lighting load, we submit the following:

One 400-cp. street lamp is equivalent to:
One residence customer with a full connected appliance load, or
Twelve electric washing machines, or
Four electric irons, or
Thirty vacuum cleaners, or
One brightly lighted store window (four 100-watt lamps and reflectors).

To give an idea of the additional revenue available from improving street and highway lighting we present the following:

(a) If the cities of Portland, Spokane, Ogden and Salt Lake would bring their annual expenditures for street lighting up to the average spent by 218 cities in the United States during 1930, there would be added to the central stations' revenue an annual increase of $128,963.

(b) If the cities of 1,000 or more in Oregon, Washington, Idaho, Montana and Utah that do not have ornamental street lighting systems would install a system on the same per capita basis as that installed in Kennewick, Wash., (population 1,519), November of last year, there would be added to the annual revenues of the central station, $205,305.

(c) If the cities within the Northwest Electric Light and Power Assn. territory, excepting the large cities mentioned above, would increase their expenditures for street lighting 21.8c. per capita, or the average spent per capita in the United States for street lighting, there would be an additional annual revenue increase of $237,100, making the total estimated annual revenue increase from these three sources alone $571,368.

(d) If the mile of heavily traveled highway in the Northwest, paralleled by pole lines, were to be lighted by seventeen 400-cp. lamps per mile, at a rate of 1½c. per kw.-hr., there would be added to the annual revenue of the central stations $1,128,325.

As an illustration of the increasing necessity for highway lighting, as well as adequate street lighting, we submit the following figures from a report of the New York State Motor Bureau:

ALL REPORTED ACCIDENTS

Day accidents in 1927 were	41,502
Day accidents in 1930 were	55,683
Increase in day accidents in three years	36%
Night accidents in 1927	29,724
Night accidents in 1930	41,601
Increase in night accidents in three years	40%

It is obvious that the number of accidents occurring at night is increasing at a more rapid rate than those which occur in the daytime.

FATAL ACCIDENTS

Day fatal accidents in 1927	1,159
Day fatal accidents in 1930	1,276
Increase in three years	11%
Night fatal accidents in 1927	9917
Night fatal accidents in 1930	1,313
Increase in three years approximately	43%

This is the situation in New York State. We quote these figures because they happen to be available. They point to the fact that both fatal and non-fatal accidents occurring after dark are increasing at a higher rate than those accidents which occur in the daytime. Highway lighting will help to decrease the number of accidents at night. Everyone should be interested in promoting highway lighting. This committee believes that such effort on the part of this association would be attended by satisfactory results. We again recommend that something be done about it.

FLOODLIGHTING

The foregoing remarks on street lighting are applicable to a very great extent to floodlighting. The latter does not possess, obviously, the economic and social value that does street and highway lighting, but it nevertheless has a very distinct value to the central station, and by a complete survey of the territory served, innumerable applications for floodlighting service can be developed. We recommend close cooperation with equipment manufacturers in their sales campaigns, and direct personal and direct-by-mail solicitation of the floodlighting load from prospective customers. Central station companies should set the example for prospective customers by illuminating their own properties. By intelligent application of floodlighting units, many activities may be carried on at night, which heretofore have been confined entirely to daylight hours. We attach to this report a list of floodlighting applications. In this report, the term floodlighting is understood to mean general illumination of areas of activity, as distinguished from the strictly advertising application.

Although the floodlighting load compares favorably with the appliance load, there is no conflict in the promotion of both. The floodlighting dollar is spent by a different group from the group which spends the appliance dollar. The annual kilowatt-hour consumption of one 750-watt floodlight, operating until midnight, equals:

One range, or
Three water heaters, or
Seven radios, or
Three electric refrigerators, or
Thirteen washers, or
Fifteen electric irons, or
Two average residence customers.

The annual kilowatt-hour consumption of one 750-watt floodlight, operating all night, will practically double the above figures.

Bear in mind, however, that floodlighting projectors are seldom installed singly. They are usually installed in groups.

AIRPORT AND AIRWAY LIGHTING

This field is still in a state of flux, but offers for a few years at least a fairly profitable though limited, field for central station lighting service. In some quarters, it is thought that the development of the autogyro type of plane will considerably change the

type of landing field and its lighting requirements. At present, most of the activities in connection with airports and airways are undertaken by the Aeronautics Section of the Department of Commerce of the United States government. Your committee has no special recommendations for the development of this particular field.

MUNICIPAL STREET LIGHTING ANALYSIS

City..... County..... State.....

Date..... Area in sq.mi.....

Population..... Assessed valuation.....

Tax rate used .....mills. Tax rate limit.....

	Residence Utilitarian Lighting	Business Ornamental Lighting	Through Street Highway Lighting
Miles of streets.....	.....	.....	.....
Miles of lighted streets	.....	.....	.....
Miles of unlighted streets	.....	.....	.....

	Last Year	This Year
Total amount raised by taxation....	.....	
Total amount to be raised by taxation		.....
Amount expended for municipal administration including bonded indebtedness	.....	
Amount appropriated for municipal administration including bonded indebtedness		.....
Amount expended for street lighting	.....	
Amount appropriated for street lighting		.....
Amount expended per capita for municipal administration.....	.....	
Amount appropriated per capita for municipal administration.....		.....
Amount expended per capita for street lighting	.....	
Amount appropriated per capita for street lighting.....		.....
Cents per tax dollar for street lighting	.....	

Number and sizes of lamps

Residence	Business	Through Streets

HIGHWAY LIGHTING ANALYSIS

County ..... State.....

1. Miles of highway lighting now served..... .....

2. Number of railroad crossings unlighted and number of bad turns or other hazardous locations that could be advantageously and economically lighted..... .....

3. Miles of highway carrying approximately 250 vehicles per hour in both directions, night traffic, paralleled by pole lines available for highway lighting systems:

   (a) Main highways..... .....

   (b) Feeder highways..... .....

*Electrical Advertising**

RECENTLY some of the newspapers printed an article saying, "In intelligent, forceful advertising lies the way to better times." Your committee feels that if newspaper, magazine and radio advertising will aid the return of better times, the same holds true of electrical advertising, a subject in which we are vitally interested.

The merchants are being continually advised to do more and better advertising. It is heard on all sides and most recently from Washington in a radio address delivered by Dr. Julius Klein, Assistant Secretary of Commerce. It seems to the committee that while the merchants are at this time being urged to advertise, we, as lighting men, must not be asleep to this opportunity. Let us organize our forces to sell better and more intensive electrical advertising. The committee has divided this subject into three subdivisions: signs, floodlighting, and show window lighting.

ELECTRIC SIGNS

A survey of the business district of any community, large or small, will prove convincingly that the market for electric signs is far from saturated. There are certain businesses that have adopted electrical advertising and depend upon it to bring in a large percentage of the daily sales or patronage. Included among these are theaters, restaurants, drugstores, garages, barber shops, etc. There are still many places of business, however, which have not accepted the sign in its fullest possibilities. A well-designed sign can be more than a location marker. It is intended to do a selling job, to say or to suggest what the advertiser wants the public to purchase. It reaches the people when they are in the merchant's vicinity, while most other forms of advertising deliver the message at a distance from the point of purchase.

Are we organized to tell the right kind of a sales story from the advertiser's point of view—in other words, are we stressing advertising, or just an electric sign?

The committee realizes that a great portion of the Northwest territory is made up of small communities having only a few hundred or a few thousand inhabitants. Electric service has been extended to these communities at considerable expense. The return from commercial lighting is usually low in proportion to the investment. Electric signs have a relatively high load factor. They are in use from four to six hours per day throughout the year. On the other hand, there is perhaps no agency that can do more to vitalize business in the small town than a display of electric signs along its main thoroughfares. Your committee has in mind one community of two thousand population where the leading merchants arranged a campaign to urge every business house to display an electric sign. What was good for the community in this case was better for the individual. The small-town business man has few opportunities to advertise and this is a form of advertising that will reach his entire clientele, or patronage.

Too often the development work in this field is left almost entirely to the sign companies. In many cases,

* Report of the electrical advertising committee, lighting bureau, Commercial Section, J. H. Shaw, Utah Power & Light Co., chairman.
Benjamin Electric & Manufacturing Co.: Raymond Ackerman.
Edison Lamp Works: Ernest L. Dee.
General Electric Supply Corp.: Elmer Johnson.

due to the distance of travel involved and the small number of sales obtainable, sign salesmen find it unprofitable to cover thoroughly our smaller communities. Here opportunities are lost unless the power companies are in a position to make the contacts.

Your committee urges closer coordination of the sales programs of the sign manufacturers and the lighting departments of the central stations. The lighting men should be schooled to sell the idea of electrical advertising. With a little study of the subject and the help of the manufacturer, he can ascertain just what information is needed by the manufacturer before a design and estimate of cost can be furnished to the prospect.

One power company reports a very satisfactory working arrangement whereby the salesman sends a tentative sketch and the necessary information to the sign company. The design is made up and returned, together with a price for the sign. In this manner little time or expense is involved and many sales are consummated.

In some cases it may be desirable to sell signs on extended terms, the power company carrying the paper. However, this is a matter to be determined locally.

Certainly, the sign load is highly desirable and, in cooperation with the sign companies, a plan to increase sales should be worked out.

In larger communities the problem is less difficult, but the promotion of sign sales should form an important part of the lighting sales program.

Neon-tube signs have met with considerable success in recent years. They were more readily sold, due to small current consumption and because they were different. At first they met with a small amount of disfavor on the part of central stations because of low power factor. However, the committee feels that in a measure the sale of these signs has been a boon to the lighting industry. Thousands of neon-tube signs have been sold to customers who would not have purchased any other type of sign.

While the power factor of the individual sign is usually less than 50 per cent, this has hardly any appreciable effect on the power factor at the substation. The sign load represents only a small percentage of the total carried in the average lighting installation.

On the other hand, the low operating cost is conducive to more hours of usage, a fact that can be capitalized by the central station. In other words, why not explain this low operating cost to the consumer and suggest that he burn his sign all day?

The novelty of neon signs decreases as the number of them increases. This is paving the way for the sale of signs embodying the combination of neon tubing and incandescent lamps. These offer the possibilities of more light, a variety of colors and many forms of motion. There are still many opportunities to sell luminous glass letter signs. These are both inexpensive to install and to operate. They are legible at greater distances by day and at night. They serve the purpose of the small advertiser and also of the large advertiser in many cases, to identify the point of purchase for a nationally advertised product.

There is also a demand for changeable copy electric signs, both of the indoor and outdoor type. The advertiser changes his copy frequently in newspaper, magazine and radio advertising, so why should he not be able to do likewise in his electrical advertising?

The committee wishes also to urge the sale of more indoor and window signs. These are needed for directional purposes in many types of buildings. This load is highly desirable because such signs are used many hours each day.

Floodlighting

Each year sees an increasing use of floodlighting for advertising purposes. Where formerly its applications were almost entirely limited to the larger and more prominent buildings, the field has been extended to the smaller business institutions, even to the gasoline filling station and the roadside refreshment stand. The laundry, the small industrial plant, the bakery, the dry-cleaning establishment, and literally hundreds of institutions in the outlying sections of cities and in the smaller centers find floodlighting an excellent means of favorably impressing the public. The cost of such advertising is small and the return on the investment cannot be questioned.

It should be emphasized, however, that it is the obligation of the lighting man to lay out each job adequately. In other words, we should never sell a 1-kw. installation where 3 kw. or 5 kw. are required. Unless the customer can see a marked improvement in the appearance of his building, he is not likely to be satisfied, nor will the job set an example to be followed by others. Competition is the spice of lighting, as well as of other things, and it has been found by experience that a floodlighting job, well done, will lead to more work to be done.

Since the advent of the open-type floodlighting unit, the problem of lighting such places as gasoline stations and roadside refreshment stands has been simplified. Because of their widespread distribution characteristics, they can be mounted close to the building and serve to light both the building and grounds.

In most instances, to properly light a corner service station requires the use of three 1,000-watt or 1,500-watt units. This additional wattage is usually equal to or greater than the load already installed in the building. The committee has noticed that, in spite of the recent tendency to curtail expenses, in very few cases was floodlighting discontinued. In fact, in many districts the floodlighting sales of 1931 exceeded those of 1930.

One company reports highly satisfactory results in selling this type of lighting by demonstration. A portable rig is made up of a telescoping standard, built of steel pipe in short lengths. The base of the standard is then fitted to a hinged arrangement mounted on the running board of a small service truck. With this arrangement, the saleman and one service man drive to the prospect's place of business in the evening. It is an easy matter to raise the pole to the desired height with an open-type floodlighting unit mounted on top. This is attached to the nearest outlet by means of a long flexible cord and the demonstration is complete. This has proven a very effective means of enabling the customer to visualize the value of floodlighting to his business. As the demonstrations are made only at night, the truck is, of course, available for other purposes during the day.

The cost of suitable standards on which to mount the equipment may sometimes prove an obstacle in the selling of these units. The committee wishes to urge a lenient policy on the part of power companies and traction companies in lending the use of their poles for the mounting of floodlights. Where such poles are not conveniently located, it becomes necessary to sell the customer metal standards suitable for this purpose. One company reports the use of salvaged gas pipe in the making of inexpensive standards, which can be sold at a profit for $9. These are entirely satisfactory for this purpose and have made possible many sales where higher priced standards might have been prohibitive.

There are many other fields for floodlighting. The larger commercial type of structure, both new and old, offers an opportunity. Vast sums are invested in the exteriors of buildings to create favorable impressions of the institutions they house. At night all this beauty is lost. At small cost, such buildings can be made even more appealing after the sun goes down. The closest cooperation with architects is urged, so that floodlighting may be incorporated in the plans of future buildings. In this respect, luminous decorative features and mobile color lighting should not be overlooked.

The industrial field is one of vast size, that has hardly been scratched. There are many factories located along the highways and the railroads. Floodlighting, besides serving the industrial institution as an advertisement, also is a means of protecting its property against theft or vandalism. High stacks and water towers are excellent advertising mediums. These usually have painted signs. Here, light also plays an important part in providing safety for air travel.

The floodlighting so far discussed has to do mostly with advertising for a commercial profit, but there is another field that should not be overlooked; that of public property, such as state capitol buildings, city halls, libraries, statues, memorials, fountains, parks, etc. Some of these are to be found in communities of every size.

Show Window Lighting

With the tendency toward more intensive advertising, the show window naturally will play an increasingly important part in the merchandising program. Show windows are indispensible to the modern store, and in these days of intense competition, shoppers are more discriminating and pay more attention to displays in windows than for sometime past. As always, we find all sorts of merchandise at various prices, but retailers are making a special effort to emphasize values.

Every wide-awake merchant of today knows that his wares must be seen before they can be sold. "Get it out on display" seems to be an almost universal slogan. But it is one thing to arrange an effective display and it is another to make it attention compelling. And this is where light comes into the picture. Of all tools at the disposal of the displayman, none is more interesting or holds more possibilities than light.

We have during the past few years, seen the standards of intensity in show window lighting steadily increase. There is nothing to indicate that they have yet reached the ultimate level. Many of our customers who have in recent years improved their window lighting, are prospects today for better jobs. Competition is increasing the importance of the show window as a selling medium.

In this connection, let us emphasize one point. In relighting a show window, we should never do a halfway job. We should remember that the customer buys lighting as a business-increasing service, just as he buys other advertising. If the job is well done, he will gladly foot the bill. If, on the other hand, the new lighting is not many times better than what he had, disappointment will result and he is apt to feel that he has invested his money to no good end.

A common question from lighting salesmen is "Where do you find a merchant, these days, with enough money to relight his show windows?" In one city of 130,000 population in the Northwest, there were sold during 1931 80 jobs of show-window lighting, amounting to an annual estimated revenue to the company of $15,393.

We cannot overlook the fact that there have been a large number of failures in retail business during very recent times. But these have left advantageous locations open to other going concerns, that are rapidly moving into them. There is more reason than ever for the lighting man to be on the job, equipped with a special knowledge of window lighting. He should have imagination and foresight and be able to visualize the completed windows with all of the necessary lighting equipment to supply all the requirements of any type of window trim. If he can do this, the newcomers need his assistance.

The window lighting field is by no means limited to high intensity general illumination. During recent times no end of novel ways have been found to incorporate lighting in the trim of the window and in the display itself.

The lighting man should take the lead in developing this movement. He can be of considerable assistance to the displayman in this respect and can thereby promote friendly relations, as well as increase business. Naturally, the cost of operation enters into the sale of show-window lighting. Here a common fallacy should be pointed out. Too many merchants charge window lighting to maintenance, just as they do heating or janitor service. Show-window lighting has no relationship to ordinary maintenance, but should be charged to sales promotion or advertising. The store window is the face of the business. Into it people look and see the personality of the concern. If it is open, friendly and bright, they go in and buy. If it is dull, they pass it by. Let us do our part to put window lighting in its proper place in the ledger.

When it is considered that the average small shop can light its windows in the most up-to-date fashion at a cost of less than is paid for a single 100-word announcement per day over the local radio station, it is readily seen that window lighting is not expensive advertising.

Lighting Decorations

This report would not be complete without some mention of the possibilities of decorating the community with light for the Yuletide season and for other festive occasions. This is certainly advertising. It adds to the spirit of gaiety and increases business generally. No town is too large or too small thus to decorate. We know of small communities of only a few hundred people who take great pride in their Christmas lighting decorations.

This business is highly desirable, both to the contractor-dealer and the central station. The merchants of the town profit from increased sales. People drive in from surrounding territory to see the lights and naturally they spend money.

There are many methods of promoting an activity of this nature. Ogden, Utah, a city of less than 50,000 population, has for the past several years at Christmas time, decorated its downtown streets in a very novel and appealing manner. Designs made up of festooning, with colored lamps and metal lighted ornaments, are suspended across the streets above the trolley wires and are supported by the ornamental lighting standards. At the intersections are special ornaments hung higher and supported by the buildings at the four corners. Festoons are draped from the ornaments back to the buildings. Many comments on the beauty of this display have been received from many sections.

The movement, instigated by the Ogden lighting service department of the power company, has been sponsored by the retail trades division of the Chamber

of Commerce. Each year a special committee prepares the plans and estimates of cost as early as September. The merchants, who naturally receive the most benefit, pay for the materials and Ogden City stands the cost of labor for the installation. The business houses are assessed for their portion of the expense, on a front footage basis, which is collected by the Chamber of Commerce.

With the streets decorated, it is less difficult to sell lighting decorations for the building fronts. Designs for these are sketched by the lighting service department and the installations are sold by contractor-dealers. It has been found that the most effective method is to present sketches showing the building with its decorations, so that the owner can visualize the effect. Many novel designs have appeared in Ogden, some of which have received national publicity.

In such a project, it is desirable to commence the lighting early so that the merchants will get the fullest possible benefit. A celebration, including the throwing of the switch, will serve to emphasize the beginning of the shopping season. This activity is aside from the decorating of homes, which is growing in rapid proportions each year.

In Ogden's commercial Christmas lighting for last year, there were 2,000 25-watt colored lamps used in the street decorations. These brought in a revenue of approximately $700. There were also 26 buildings decorated with a total of 3,900 25-watt lamps, at an estimated revenue of $1,300 for the month. These jobs varied in size from 15 or 20 lamps on the small neighborhood store, to 800 lamps on the largest building. The street lighting was billed on a flat rate, while the building lights were attached to the customer's meters.

In closing, it may be said that your committee has purposely left out a large array of statistics, and has avoided a technical discussion of lighting practices. We have, rather, tried to promulgate sales ideas which are practicable in the smaller communities, of which there are so many in the Northwest section. On the other hand, we have tried not to overlook the opportunities to be found in the larger centers.

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*Commercial and Industrial Lighting**

WHAT is required in the field of commercial and industrial lighting at this time, in the opinion of the committee, is not so much a contemplation of the accomplishments of the past, as it is, in this new era, a concentration of our efforts to formulate further plans for the immediate present, with an eye also to the future.

Little need be said of the extreme efforts it will take on the part of every branch of the lighting industry in order to accomplish what must be done.

Architect Contacts

Much has been gained by our contacts with architects, but there still remains much to be done. The architect cannot know it all; it is beyond the human capacity of any mind to know everything about the planning, designing and construction of a modern building. He must, therefore, go to others for some of his information, which, however, does not mean that everybody who comes to his office gives him authoritative aid. The man who can give the architect information should know more about his subject than the architect, if he hopes to prove valuable. With the new materials and designs used in the construction of the present day, the architect must look to the lighting engineer as a source of information in his field.

Concentration of Effort

The lighting engineer must be honest and firm in his recommendations, in spite of opposition and the natural tendency to prefer an inferior installation at a lower first cost. The desired end may best be accomplished by education of all factors concerned: namely, the central station, manufacturers and their representatives, jobbers, architects and engineers, fixture dealers, electrical contractors and their wiremen. This should be done with the idea of bringing about a consistent recommendation for any one installation from all the above sources. If properly informed, all should agree on a specific type of lighting.

There are four principal elements to be considered in every effective lighting system: (a) amount of light needed, (b) the kind of lighting equipment, (c) proper wiring, (d) proper location of outlets. The selection of the proper type of reflecting and diffusing units is more important today than ever in the history of illumination. In the early days of lighting, a reflector was largely a device for improving efficiency, because of the necessity of conserving light from the small low-wattage lamps then in use. Today's lamps have outgrown the old-type reflector, calling for intelligent selection of equipment for all the attributes of modern illumination. Many inferior types of equipment are sold, on claims leading the buyer to think that they possess some magical property. Some users, influenced by price alone, will install anything of reasonable appearance, without regard to its merit as a lighting device.

We have occasional installations where it might be said that we have our own way in regard to wiring and lighting, and, unfortunately, in some of these cases there has been a tendency to "oversell" an installation. Great care should be exercised in these cases; if the ultimate reaction on the part of the consumer is a series of complaints to the central station, this will be a reflection on all parties to the transaction, and in the end the installation will become inferior in both wattage and foot-candle intensity.

Foot-Candle Intensities

Foot-candle intensities are continually on the increase. Where a year ago we recommended 10 to 15 foot-candles, we are now urging 20 to 50 in some installations. This has a particular effect on small installations, where the intensity always has been low. The following table was taken from an article by Mr. Luckiesh in *Electrical World* for January, 1932, p. 183, "Considering Old Eyes in Lighting." It shows change in size of pupil with age, relative brightness of retinal images, and required levels of illumination at various ages, based on the effectiveness of 20 foot-candles at 20 years of age.

Legislation for Adequate Wiring

In some cities, adequate wiring is now being required by law. This is going to be a great help for the future in preventing buildings from being underwired, but

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* Report of the commercial and industrial lighting committee, lighting bureau, Commercial Section, M. S. Glenn, Northwestern Electric Co., chairman.
General Electric Supply Corp.: E. M. Kerr.
Pacific Power & Light Co.: H. C. McDaniel.

EFFECT OF AGE ON RETINAL IMAGES

Age	Pupil Diameter in daylight mm.	Relative Brightness of Retinal Images	Foot-candles for Equal Effectiveness
20	4.7	100	20
30	4.3	84	24
40	3.9	69	29
50	3.5	55	36
60	3.1	43	46
70	2.7	33	60
80	2.3	24	82

even with the most rigid code, there still remains a selling job to get proper capacities installed to allow proper foot-candle intensities. A very interesting article by A. Penn Denton, engineer-director, armored cable section of the N.E.M.A. in *Electrical Contracting* reads as follows:

Can We Legislate Adequate Wiring?

Adequate wiring is difficult to define, since adequacy is relative only, so we are primarily concerned with the degree of standards of adequacy. It is the standards of adequacy in wiring which the industry should be concerned with and preparing at this time, because we have always lacked them.

In my opinion, standards of adequacy in wiring must be divided into two groups. In group one, we may place all wiring regulations or standards which provide, as in our National Electrical Code, a minimum safe wiring installation which assures the public using the electrical service, safety from the standpoint of casualty and property hazards.

In group two, we shall place the standards which provide for a super or superior wiring installation, which will include copper capacities 50 to 100 per cent greater than the immediate connected load will require to assure the safety of life and property.

The wiring standards of group one have always been, and may always be, adopted by legislation and enforced by the insurance or governmental inspection authority.

The super standards of group two, while desirable at all times, and approved by our industry, cannot be enforced by legislation, since all that public interest demands is a minimum degree of safety in the wiring installation. Our group two standards of adequate wiring we must sell as a commercial problem, one that concerns all groups of the industry.

It is true, and of great interest to note, that, as our industry has grown, the maximum or super standards of one period become the minimum safe standards of a decade later.

A recent survey made in Chicago developed the startling fact that practically all commercial and residential buildings built in that city in the three or four years prior to the time the survey was completed, were either loaded to capacity, or so overloaded as actually to become, in many cases, electrical fire hazards. This same condition of inadequate building wiring is common to all cities.

Referring again to minimum safe wiring standards, there is much we can do to improve the minimum regulations of local and national codes. The contractors and inspectors should be particularly concerned with improved minimum adequacy standards for wiring.

Too long we have guessed at wattage values for given outlet or circuit needs. The Society for Electrical Development, in the studies which Arthur L. Abbott has made, has developed valuable data for minimum branch circuits and outlet requirements, giving wattage standards for given units of floor area, which should be adopted as minimum standards in our local and national codes. Similar requirements are needed for commercial and industrial buildings.

We need improved standards of adequacy which should be minimum safe code requirements for services and feeders, both lighting and power wiring, based on building size and floor areas.

Central stations and contractors, through cooperation with local inspection departments, can accomplish a great deal to improve the present standards of wiring, first, by having a rigid wiring code, and, second, by enforcing it. This, together with the personal contact of the lighting engineer with owner, architect, and contractors, will build lighting intensities on new and remodeling work to a point somewhere near what they should be, and be the means of selling more killowatthours, as well as an increased volume of wiring materials and fixtures.

Electrical Code Revision

In the city of Portland, Ore., there is under way at this time a revision of the wiring code which will eliminate many of the stumbling blocks that lighting engineers have had to contend with in the past. L. W. Going, chief inspector of that city, has been very conservative in these changes and has given every consideration to all concerned.

The following is a section taken from the revised code dealing with commercial, industrial and public buildings:

(a) The requirements of this section shall apply to the wiring installations of all buildings, except buildings occupied as single-family dwellings and multi-family dwellings, or apartment hotels having provisions for cooking in individual apartments, and except industrial plants and buildings with interiors requiring special treatment, such as large auditoriums, theaters, banking houses, etc.

Branch Circuits—Number, Size and Length

(b) At least one branch circuit shall be installed for each 1,000 watts, or fraction thereof, of the standard load, computed in accordance with paragraph (f) to (l) inclusive, of this section, except that, where a definitely predetermined load is to be supplied and the conditions are such as to make it unlikely that lamps of higher wattage will later be installed or that portable equipment will be connected with the circuit, one branch circuit may be installed for each 1,500 watts of load. The arrangement of circuits shall be such as to permit the use of the standard loads specified without exceeding the permissible wattage per circuit.

(c) No conductor smaller than No. 12 B.&S. gage shall be used in branch circuits.

(d) Panelboards shall be so located that no circuit run will exceed 75 ft. from panelboard to the first outlet. Where runs exceeding 75 ft. from panelboard to the first outlet cannot be avoided, the initial load shall be limited to 750 watts unless No. 10 wire is installed.

(e) Panelboards shall contain one spare circuit position for each nine circuits, or major fraction thereof, in service. Provision to be made for spare circuits to be picked up above baseboard.

(f) The standard load for general lighting shall be deemed not less than 2 watts per sq.ft. of floor area, except as otherwise required or provided in the following table:

	Watts per sq.ft.
Drafting rooms	5
School drawing and art rooms	5
*Hospital wards or private rooms	2
Auditoriums	1
*Hotel guest rooms	2
Hallways, corridors and stairs	½
Storage spaces	¼
Toilet and washrooms	1

* Includes both lighting and appliance outlets.

(g) Standard load for the general illumination of show windows shall be deemed not less than 100 watts for each linear foot of plate glass, measured horizontally, and 50 watts outside of the brightly lighted districts.

(h) The standard load for showcase lighting shall be deemed not less than 25 watts per linear foot of showcase or wallcase frontage.

(i) Provision shall be made in store buildings for the connection of an exterior electric sign by installing not less than one sign outlet for each store. The minimum capacity provided for any sign outlet shall be 1,000 watts for each 25 linear ft., or major fraction thereof, or store-window display frontage.

Standard Load for Appliance Outlets

(j) In the guest rooms of hotels and in wards or private rooms of hospitals, the standard load specified in paragraph (f) may include both lighting and appliance outlets. The total number of light and/or appliance outlets supplied by branch circuits in such rooms shall be divided equally between these circuits.

(k) In all other locations, the minimum rating of appliance outlets shall be taken initially as 125 watts each, when computing the standard load.

(l) Appliance outlets shall not be placed on the same circuits with outlets for general or special illumination. Appliance outlets used for manufacture or repair spaces shall be wired with not less than No. 10 wire and fused at 25 amp.

Appliance Outlets Required

(m) In stores having supporting columns, there shall be installed at least one appliance outlet on or in each of the supporting columns. In stores having no supporting columns, there shall be installed at least one floor outlet for each 400 sq.ft. or major fraction thereof, of floor space, these outlets to be uniformly distributed over the entire area.

(n) At least one appliance outlet shall be provided in show windows for each 5 linear ft. or major fraction thereof, of plate glass measured horizontally.

(o) In each separate office room, hotel guest room, hospital room or ward with 400 sq.ft. or less of floor area, there shall be installed at least one appliance outlet for each 20 linear ft., or major fraction thereof, of wall space, such space to include all openings. In each such room with more than 400 sq.ft. of floor area, there shall be installed at least four appliance outlets for the first 400 sq.ft. of floor area and at least two additional appliance outlets for each additional 400 sq.ft., or major fraction thereof. Outlets shall be so placed as to serve all parts of the room.

(p) In hallways and corridors there shall be installed at least one appliance outlet for each 40 ft. of wall space, such space to include all openings.

SECTION 2104—INDUSTRIAL OCCUPANCIES

(a) The requirements of this section shall apply to wiring installations in industrial occupancies. Industrial occupancies shall be deemed to include occupancies where manufacturing processes, dyeing, cleaning, testing or repair work are carried on, and spaces used for the handling and storage of materials.

Branch Circuits—Number and Size—

(b) At least one branch circuit shall be installed for each 1,000 watts or fraction thereof of the standard load computed in accordance with paragraphs (f), (g), and (h) of this section, except that in locations where a definitely predetermined load is to be supplied and the conditions are such as to make it unlikely that lamps of higher wattage will later be installed or that portable equipment will be connected to the circuit, one two-wire branch circuit or one side of a multi-wire branch circuit may supply as much as 4,000 watts load.

(c) The arrangement of circuits shall be such as to permit the use of the specified standard load per unit of floor area without exceeding the permissible wattage per circuit. It is provided, however, that exposed circuit runs which do not supply more than twelve outlets, nor more than 1,200 watts connected load (per side) may supply greater floor areas. This shall not, however, be construed to permit a reduction in the number of branch cutouts required at distributing centers.

(d) No conductor smaller than No. 12 B.&S. gage shall be used in any branch circuit. Branch circuits supplying appliance outlets in working spaces shall be wired with not less than No. 10 wire.

(e) Panelboards shall contain one spare circuit cutout for each five circuits, or major fraction thereof, in service.

There are also a number of changes in demand calculations for services and feeders, the application of which has raised the standard considerably. Reinspection of wiring, fixtures and appliances in present commercial and industrial buildings will help us get more load, giving an opportunity for the lighting engineer to make his contact and to recommend modern lighting. This work is now being started in Portland, Ore.

INCREASED SALES OBTAINED BY PROPER ORGANIZATION

Replacing burnt-out lamps or filling empty sockets in stores and windows has been found by experience to be a true method of adding load and boosting lamp sales. This method of securing load should have a systematic follow-up on later dates, in order to make the loads permanent.

In every commercial and industrial installation where proper application can be given, specifications and wiring layouts are being made to provide for the use of sunshine luminaires.

A definite trend toward semi-indirect and totally indirect lighting, each in its proper application, is to be noted. However, there still remains much to be accomplished. Contractors still make many of the contacts, and the majority of these are willing cooperators with the central stations. Through this cooperation, and through the follow-up of permits for remodeling, we have an excellent opportunity for securing better illumination and load building. It is through such combined efforts, that at the present time a large chain grocery in the city of Portland, Ore., is completely remodeling and relighting approximately 30 stores, with an increase of from 3 to 5 kw. in lighting in each store.

Many excellent lighting campaigns are now being offered by manufacturers, and, with the cooperation of manufacturer's representatives and jobbers, very good results have been obtained.

*Domestic Lighting**

THE most perplexing merchandising problem with which the lighting industry has ever been confronted is that of awakening housewives to the beauty, comfort, convenience, safety and inexpensiveness of good lighting in their homes.

The plumbing industry has made marvelous strides in its field and with apparently greater handicaps than lighting has ever had. A modern bathroom, modestly done, often costs as much as the entire wiring and fixture job of a home. Yet today, an acceptable bathroom has reached such a definite standard that there is little or no question about this necessity, the only question being that of how luxurious a job can be afforded. Curiously enough, we do not have to go back so many years to find that legislation frowned upon the taking of baths, and earlier still, we are informed that the medical profession had many arguments against bathing, and particularly against frequent bathing.

Next in order, let us look at what the furniture manufacturer has accomplished. All of us have been attracted to better-designed furniture and, accordingly, have placed pieces of furniture on the third floor or have sold these pieces to second-hand men. Not because the discarded furniture was beyond usefulness, but because somehow we have been taught to appreciate the difference between the monstrosities of our homes of a generation ago and the beauty of the refined designs of today. Likewise, the heavy, dark and overornate wallpapers have given way to the lighter colored and more softly blended designs.

Go into the furniture store and hear how even the average salesperson glibly talks of provincial pine, satinwood, lacewood, period styles and a dozen other things that pique our interest. In contrast, go into a lighting fixture store, or, in fact, into many of our central station fixture departments, and you will be disappointed if you expect to find the same intelligence on lighting for the home. If you doubt this statement, go into as many places as you may care to, and your doubts will be quickly removed.

We have unquestioned excellence in the personnel presenting the story of cooking, washing, ironing and so on, but in only a relatively few cases do we have talent that can prepare specifications or select the right things in lighting for even a modest home. Even our sales people, home-service women and others regularly contacting the general public, discuss lighting without competent knowledge as to the proper lamp for the required use, effect of undervoltage burning of lamps, or general operating characteristics of lamps. In many retail stores of various utilities, we find employees selling 25-watt or 40-watt lamps for kitchen lighting. All of us realize that such a sized lamp would utterly fail in lighting the average kitchen adequately. Similarly, this condition, or others equally as bad, are found among average retail lamp dealers.

The mazda lamp manufacturers, through personal contact and instruction, are rapidly educating their dealers' organizations in proper lighting requirements, as well as through a tremendous educational advertising program in national magazines.

On the other hand, go through the local newspapers

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* Report of the domestic lighting committee, lighting bureau, Commercial Section, Walter E. Potter, Incandescent Lamp Department of General Electric Co., chairman.
Incandescent Lamp Department of G. E. Co.: Darcy Van Alstyne.
The Washington Water Power Co.: Ladner V. Ross.

and count the column-inches of advertising, editorial and feature-article space for a week which are devoted to all things pertaining to the home, and place alongside this figure the column-inches on residential lighting of any character. We all know the answer—hundreds, in fact, thousands to one. How then can we expect to change the attitude of indifference toward lighting?

Actually, we have more than indifference to overcome, for we have with us a negative attitude which we may as well consider a habit, for it has been growing on us for so many centuries—a habit possessed almost universally by all of the civilized nations and which, in turn, retards the progress of electric lighting in the home. What is this habit? Simply stated, it is the desire to economize wherever artificial light is involved! One hundred and forty-six years ago, Benjamin Franklin wrote an essay entitled "An Economical Project," which illustrates the desire to save at that time where artificial light was involved. In this essay, he relates of seeing for the first time a new lamp fed by oil and, in going on, states, "Its splendor was admired by all, but" (as he phrased it) "no one present could satisfy the assembled group as to the economy of the device." For, as he continues, "All agreed that the economy of this new lamp ought to be known," for it would be very desirable to lessen the expense of lighting, because every other item of family expense had markedly increased. This desire to reduce the lighting bill of the country leads him, in a serio-comic vein, to elaborate in detail on a method whereby a vast sum could be saved, namely, "that people arise at sunup, thereby exchanging the early hours of free sunlight for several hours of being about at night, with the attendant lighting cost." Franklin's essay, while amusing when viewed today, was at that time somewhat justified, for lighting by means of candles was very costly in those days.

Despite the phenomenal reduction in the cost of light since Franklin's time, this inherent desire to save and economize is still with us. Even today, many would join the group that we jokingly hear about, leaving the theater to rush home and back in a taxi, costing $2.00, just to turn off a 40-watt lamp which had been left burning in the basement. Actually, that basement lamp could be burned day and night for five weeks before the price of the taxi ride would have been equalled.

Obviously, this miserly attitude cannot be ignored in the future development of home lighting. While people are quite indifferent toward lighting, they are not indifferent to its cost. Of course, this is an unjust attitude, as it is exceedingly difficult to find anything for which an entire family spends seven cents a day which compares with the electric service obtained.

Despite the fact that no laboratory has ever devised methods which will (1) really remove wrinkles or rejuvenate, (2) really prevent shiny noses, (3) really grow hair or remove it permanently and inexpensively, the total 1929 expenditure for cosmetics, perfumes and other toilet preparations and personal services rendered at beauty shops amounted to approximately $750,000,000. It will be noted here that this amount is equal, if not greater than that spent for electric service in all the homes of the country. Actually, few women do anything about making themselves more than presentable, if that. But many more do so now than ten years ago.

This amount of money which was spent to be made attractive, presentable, or whatever you choose to call it, is undoubtedly due to the desire for creating personal self-satisfaction and the natural urge to appeal to the opposite sex. Under this latter heading, the urge is largely a matter of getting a husband or of holding a husband. Surely we can have no quarrel with this desire to make the world a pleasanter place in which to live.

While the natural urge to look one's best is found in all of us to a greater or lesser degree, no one can doubt that the educational program of the cosmetician has done much to create a greater interest in woman's appearance. This educational program, while filled with fine shades of meaning, resolves itself after all into that of interesting advertising copy and example.

After woman, in playing her natural part in seeking a life companion, finds this companion, she still has the problem before her of creating a home. The intelligent woman has come to realize the importance of the home in keeping the family intact. First her own character, next her personal appearance, and then the home itself, must be dovetailed together to produce a harmonious and inviting place in which to be.

This same intelligent woman, when shown the importance of lighting in her home in relation to the other elements in which she has already shown such vital interest, will not tolerate the lighting which she is blindly accepting today. Lighting cannot be packaged and, accordingly, does not readily lend itself to the more usual merchandising methods employed when a three-dimensional piece of merchandise is involved.

Correct and proper lighting can be sold and appreciated by the average woman, providing it is presented along the lines of beauty, comfort, convenience and safety. Consider those four fundamentals, and you readily realize that all articles in the home today are purchased on those lines. When you bought your new automobile recently, was it not sold to you (without mention of price at all) on its beauty, comfort, convenience and safety? Certainly it was, no matter what the make.

An additional new indirect floor portable lamp, using a 300-watt lamp, has beauty in itself, comfort in elimination of eye-strain and mental and physical fatigues, convenience in furnishing plenty of proper light when and where you need it, and, lastly, safety in the elimination of shadows lurking in dark corners, as well as the protection offered.

Actually, while the merchandise, the fixture, the bracket, the table and floor lamp are the tangible things involved, the real thing to be merchandised is the lighting result. Houses already have ceiling fixtures in the important rooms of the home, so that new fixtures, as such, are not needed. But when a real improvement in lighting can be made with a new fixture, bracket, or lamp, and the housewife is afforded an opportunity to see and live with this improvement, she can be made to appreciate the lighting result. Furthermore, field experience proves this to be true. Demonstration can turn the trick, but can we afford to send solicitors from door to door with a lighting fixture, portable lamp, etc., to make such demonstration? From the increased revenue collected during the ensuing years, yes; but from the merchandising profit point of view, it is very questionable.

How then, should this field be developed? There is the short duration method of highly intensified nature and the systematic year-round method. Due to the barrenness of the soil upon which the short intensive activity must be built, we can hardly justify this means to an end at this time.

On the other hand, there are so many elements influencing the thinking of the domestic customer, that

there can be no stone left unturned which will in any way influence his thinking. If, in every public place having a residential character, the residential customer saw good examples of home lighting, the effect would be telling. The furniture stores are showing their wares in partially or completely constructed rooms. Are these rooms lighted in the best manner? Various associations, such as the face-brick association, the lumber associations, etc., are building display homes from time to time in the larger cities. Are those homes lighted in the best manner? Newspapers and local magazines are either describing or pictorially presenting newly built homes. Do these stories and pictures tell a story of the better things in home lighting? Fixture stores and interior decorating shops deal directly with the subject. Do they do it justice? Electrical homes, sponsored by the electrical industry, afford real opportunity. Have they always carried a correct message? The answer is practically an unqualified "no".

Magazines and general publications of the home, such as McCalls, House and Garden, Pictorial Review, Ladies Home Journal, and similar organs, are constantly carrying the message of correct and proper home lighting directly to the consumer, especially to that type of home wherein lies our greatest and most profitable market. Every phase of residential lighting is discussed in these articles, including adequate wiring and even ultra-violet irradiation.

Short-duration lighting campaigns are certainly not going to change this condition, but a residential lighting specialist whose full time is devoted to the development can. Until such a person exists in a given community, sound progress will not be made.

The character of the work undertaken might be purely educational at first, just as the lighting department activities in the commercial and industrial fields are today. However, since we have an entire community to educate, rather than a limited business group, the results will of necessity be more slowly obtained. Knowing, as we do, that the total gross awards will be greater than those obtainable from all the other fields, residence lighting deserves at least the same attention that the many commercial applications of light are receiving, and surely not less.

An expenditure for a portable lamp using a 200-watt lamp equals the combined revenue produced by a flat iron, toaster, percolator, vacuum cleaner, washing machine and a fan. In recent years the only residential lighting activity has been the promotion of a kitchen lighting unit, usually with a medium-priced unit. Furthermore, this particular unit has been restricted in its use in the home, primarily to the kitchen. Little or no attempt has been made to increase our revenue in any of the other rooms of the house.

Everyone of our central stations has a considerable number of low-use domestic lighting or minimum bill customers that are quite unprofitable. Lighting equipment has been designed quite recently to build up the load of these unprofitable domestic customers and several of our utilities in other communities have brought a great percentage of these accounts into the profitable class. The units designed involved three main factors: (1) an obviously increased current consumption; (2) an honest and appreciated service to the customer; (3) an elimination of sales resistance through a low initial cost.

In addition to the minimum-bill customer, there are millions of domestic customers that need and can use to their advantage better illumination in every room in the home. This includes our homes already built and those that are constantly being built and rebuilt, or remodelled annually. Additional outlets are being added daily in many homes without the help or assistance of any sales effort on the part of the industry. Many of our central stations are making no effort to develop the home-lighting market, apparently because direct results are not impressive.

The domestic lighting committee of the Commercial National Section of N.E.L.A. has developed a three-year plan directed towards all domestic lighting customers and has made available through channels a home lighting manual, of which Part One is a prospectus entitled "A Challenge." The industry has been offered by the residential market consumer a real challenge, when we find such conditions existing as:

(1) One out of every three fixtures is unquestionably obsolete.

(2) Shaded light is the exception, rather than the rule.

(3) 32 out of every 100 lamps in sockets are 15-watt and 25-watt in size.

(4) People are allowed to feel that electric light is expensive.

(5) The homemaker is satisfied with costs of electricity for labor-saving devices, but is not satisfied with lighting costs.

(6) Prevalence of defective vision is ignored.

(7) Inadequate standards of wiring are commonly employed.

(8) Interest and sympathy of all possible cooperating forces are not coordinated.

The lamp and fixture manufacturers have agreed and are conducting a national advertising campaign over their individual names, and it is up to the Lighting Bureau in this geographic division to secure participation in this activity by as many companies as possible. A suggested year's program for home lighting activity is attached as part of this report.

Many of our central stations have availed themselves of the material offered; several have used the film-slide lectures in addressing various service club organizations and customer groups. A very few have used any of the radio time available for home lighting discussions. Several newspapers have printed advertisements sponsored by member companies.

Today, when the public utility is laboring under greatly decreased revenues, without corresponding reduction in operating expenses, coupled with discussions arising against our operations, the ray of light out of our present dilemma lies in employee education. Most of our utilities have been or are conducting N.E.L.A. employee educational classes on the fundamentals of our operations. The average individual looks to the central station employee as one who can answer all questions pertaining to the industry. Every employee has a countless number of personal contacts where information and sales information can be broadcast to immeasurable benefit.

With our commercial and industrial revenue considerably decreased, and with little hope of its showing any material return to normal, exclusive of any increase, our best and largest (as well as most profitable) field is the residential. With these facts, many of our utilities have conducted educational courses for all employees in home lighting, using the material furnished by the incandescent lamp department of General Electric Company. One small course of ten lessons has been used for all employees, with the larger course of fifteen lessons, which is more complete, for those directly contacting the public in a sales capacity. The results of this activity with one of the utilities in Portland has created considerable interest among employees, as well as increased revenue, through proper

lighting changes made by those employees in their own homes, due to knowledge obtained from the course.

Envelope stuffers have been used to create further interest on the part of the consumer in better residential lighting.

Now, it remains for us to devise a real sales activity to crystallize this interest on the part of the consumer into direct sales and additional revenue for the industry. The interest in ultra-violet irradiation has been increasing and our sales of the units are mounting rapidly, further increasing our load.

During the fall, winter and early spring months, sales activities and campaigns on sunlamps using S-1 and S-2 lamps have been conducted. A large number of units have been sold, greatly increasing the appreciation by the public of the service offered by the utilities, through further use of electricity in the home, as well as increasing our revenue through more kilowatt-hours. Many of our utilities plan extensive campaigns on this phase of lighting for the coming fall.

Central station executivies must take the lead in this program of residential lighting development—first through the development of a home lighting specialist; second, if not a home lighting specialist, we must develop our home service group. The very definition of the home service department is, first, to increase the kw.-hr. consumption and, second, to build greater goodwill through service in the home. This ideal is being only partially fulfilled when these departments are dealing primarily with appliances. A complete service in the home must include lighting and, inasmuch as there is a sizable force of workers already established among central stations, the placing of the lighting specialist with these people is the most logical. Any educational development is dependent on contacts with the consumer, and our home service women have these valuable contacts.

Our lighting departments can coordinate the efforts of the many individuals involved—first the architect, then the builder, next the decorator, and finally, the fixture man, with the dollars and cents side of the story in the background every minute.

Home service will then comprise two major activities, equal in importance: residential lighting, and those activities relative to the service of electrical equipment in the home. Facilities and audiences are items of expense. The greater spread of effectiveness which we can get from these expenses, of course, the more economical our program. Home service departments already have audiences and facilities. The audiences do not have to be changed, and the facilities are often adaptable. The usual stage kitchen or kitchen lecture platform can serve for complete discussions of the lighting arranged for each room of the home at very little cost. For, by the simple addition of draw curtains which will cover the kitchen equipment, we have the background for various rooms of the home. Furniture and other decorative details can be obtained from department stores or furniture stores at very low rental cost, or gratis, and a truly adequate and eye-appealing story can be presented.

When one-third of the ceiling fixtures in every-day use are obsolete, when the average home has but three to four portable lamps, whereas eight or nine are easily accounted for, when 25 per cent of the lamps (bulbs) are unshaded and 50 per cent of the remainder are inadequately shaded, and when the prevalence of defective vision ranges from 23 per cent of those under twenty years of age to 95 per cent of those over 65 years of age, there can be no question about the possible improvements which can be made, nor any question about having an individual whose responsibility it is to get these improvements under way and gradually adopted.

Truly, the industry has been challenged! Are we going to accept it?

Suggestions for a Yearly Program of Home Lighting Activities

January, Health Month—

(A) Eyesight conservation, fixtures and lamps for studying.

(B) Sunlamps for sunshine, for adults, children and babies.

(C) Plans for keeping Christmas tree lighting in constant use.

February, Hostess Month—

(A) Leisure time plans for children, making electric table decorations.

(B) Adult plans for Valentine's Day, Lincoln's and Washington's birthday electric table decorations.

(C) Month of entertaining, modernizing dining-room lighting.

March, Utilitarian Lighting—

(A) Campaign on kitchen lighting, 150-watt, 200-watt units, brackets.

(B) Bathroom lighting, for shaving, sunlamp for sunshine.

(C) Basement, including laundry lighting.

(D) Dark hallways.

(E) Garage lighting, including trouble lamp.

April, Modernizing Month—

(A) Modernizing home during moving and housecleaning time.

(B) Talks and plans on wiring for existing homes.

(C) Lamp renewals.

(D) Plans for summer lamp shades for homes and summer cottages.

(E) Making contact with women's clubs for place on their programs for following year.

May, Wiring Month—

(A) Talks and plans on wiring for new homes.

(B) Additional outlets.

(C) Garden lighting talks to clubs, individuals, etc.

June, Wedding and Graduation Gift Month—

(A) New homes, wiring and lighting.

(B) Wedding gifts—portable lamps, health lamps, lighted ornaments.

(C) Table decorations for graduation parties, bridal parties and showers.

(D) Employee activities, instruction in selling proper wattage of incandescent lamps, raising lighting standard of their own homes.

July and August, Garden and Winter Lighting Months—

(A) Garden lighting.

(B) Party decorations for holiday.

(C) New homes—wiring, fixture, lamp recommendations.

(D) Contacting architects and builders.

September, Fall Lamp Shades Month—

(A) Organization of lamp shade classes.

(B) Planning talks on programs for homemaking departments of public schools.

(C) Work with Girl Scouts.

(D) Study lamps for school children emphasized.

(E) Campaign on lighting fixtures.

October, Farm and Winter Lighting Month—

(A) Farm lighting activities, tying in with farm extension department.

(B) Dining-room lighting.

(C) Table decorations for Halloween, fall and winter entertaining.

(D) Campaign on indirect floor lamps, 300-watt.

(E) Campaign on empty sockets.

November, Outdoor Lighting Month—

(A) Lighted house numbers.

(B) Outdoor safety lighting, floodlights for garage driveways, entrances.

(C) Special plans for Thanksgiving lighting.

(D) Outdoor Christmas lighting contest.

December, Christmas Lighting and Electrical Gift Month—

(A) Lighting for indoor and outdoor decoration at Christmas time.

(B) Talks on new fixtures and lamps for gifts.

MERCHANDISING BUREAU[1]

*Electric Range**

AMONG the subjects which the national domestic range committee selected for its report was that of how to make the independent dealer and retail salesman a real factor in the distribution of electric ranges.

Following the lead of the national committee, we have attempted in this report to offer some suggestions for the solution of the problem mentioned above. It can be readily understood that every utility interested in developing its domestic business would profit if independent dealers would aggressively promote such load-building items as electric ranges. Independent dealers have in the past few years been attracted to the business of selling electric refrigerators, and it is estimated that 75 per cent of all electric refrigerators sold during 1931 were sold by independent dealers and 25 per cent sold by utilities. Utilities sold 70 per cent of all electric ranges sold during 1931 and independent dealers 30 per cent.

In 1931 there were approximately 900,000 refrigerators sold by all outlets, while 115,000 ranges were added to utility lines. While it is true that in the past the electric refrigerator has enjoyed a wider market, with greater public acceptance than the electric range, which elements are to a great extent responsible for the large sales of refrigerators, still it is believed that the number of retail outlets also had considerable to do with refrigerator sales. If this is true, then an increase in electric range sales should result from an increase in good electric range outlets through independent dealers. Independent dealers will become interested in the aggressive sale of electric ranges provided they can make a satisfactory profit.

Your committee believes, therefore, that it is in the interest of the public, the utility and the dealer for the utility to do everything within its power to create marketing conditions which will encourage the entrance of capable, aggressive, independent dealers into the range selling field.

[1] R. B. McElroy, The Washington Water Power Co., chairman. R. M. Bleak, Utah Power & Light Co., vice-chairman.

* Report of the electric range committee, merchandising bureau, Commercial Section, V. H. Moon, Pacific Power & Light Co., chairman.
The California Oregon Power Co.: K. G. Klahn.
Idaho Power Co.: R. S. Overstreet.
Portland General Electric Co.: O. E. Crites.
Puget Sound Power & Light Co.: R. W. Clark.
The Washington Water Power Co.: H. W. Cooper.

Merchandising Policies

In order to determine the merchandising practices now in use by the utilities of the Northwest Division, a questionnaire was sent to a representative number of utilities in this territory. The questions asked and composite answers of the utilities reporting are as follows:

What minimum down-payment will your company accept on the sale of an individual domestic range?

The general practice of the utilities reporting was to accept a down-payment of $10.

What is the maximum length of terms on which the individual domestic electric range may be sold under your policy?

From 15 to 24 months.

What carrying charge is made?

The average carrying charge for the companies reporting was slightly in excess of one-half of one per cent per month on the total deferred balance.

Are your terms met by local dealers?

Terms offered by the larger dealers who, it is assumed, are the best financed dealers, are equally as attractive as those of the utility.

Do you believe that it is necessary to continue selling electric ranges on your present terms?

The reporting companies expressed themselves as believing that the terms they were now offering were necessary to secure a satisfactory volume of range business.

Would a plan for financing dealers' range paper on comparable terms with those offered by the utility stimulate dealer sales?

Yes, and a study is being made of this problem. It is hoped a satisfactory solution may soon be reached.

Does your company favor the exclusive distribution of ranges they handle in the territory served?

We believe that the number of outlets required for the satisfactory sale of any make of electric range is a distributor's problem. The committee feels that sufficient franchises should be granted on any make of range to insure adequate sales coverage in the territory involved. We feel that the interest of the dealer, utility, manufacturer and public are best served in this way.

Now You Can Enjoy Spring Days!
Electric Cookery Gives You
This New Freedom
PUGET SOUND
Power & Light Company
"ELECTRICITY IS CHEAP"
Dutch Oven Cooking!
So Delicious..Nor So Simple!
PUGET SOUND
Power & Light Company
"ELECTRICITY IS CHEAP IN WASHINGTON"
Offer closes soon
ACT NOW!
7-PIECE ALUMINUM SET
FREE*
with the purchase of a new electric range from
Pacific Power & Light Company
or any local merchant
Right now only $5 down delivers and completely installs any electric range!
Which way . . .
would you rather cook?
FLAME COOKING?
ELECTRIC COOKING?
SEE YOUR DEALER TODAY
GENERAL ELECTRIC
Hotpoint
AUTOMATIC ELECTRIC RANGE
Mountain States Power Company
THIS $22.50 ELECTRIC MIXER
WILL BE
GIVEN AWAY
With Each Electric Range Sold By Any of the Dealers Listed Below:
ELECTRIC WIRING COMPANY
Hotpoint Ranges
JOHN CUPP FURNITURE COMPANY
Universal Ranges
MEDFORD ELECTRIC CONSTRUCTION CO.
Hotpoint Ranges
MEDFORD FURNITURE AND HARDWARE CO.
Crawford Ranges
PALMER MUSIC HOUSE
Hotpoint Ranges
PEOPLES ELECTRIC STORE
Westinghouse and Hotpoint Ranges
ROBBINS FURNITURE COMPANY
Monarch Ranges
ELECTRIC RANGES
ARE CHEAPER THAN EVER BEFORE
NO CHARGE FOR RANGE WIRING
Small Down Payment, Easy Monthly Terms
SUNBEAM-MIXMASTER FOOD MIXER FREE
THIS OFFER IS LIMITED
SEE YOUR DEALER TODAY
SEE THIS WONDERFUL MIXER AT THE MAIL TRIBUNE'S FREE SCHOOL OF HOME ECONOMICS AT THE HOLLY TOMORROW
The California Oregon Power Company

Fig. 1—"See your dealer" is the message of each of these range advertisements sponsored by different utilities of the Pacific Northwest

What percentage of the total ranges sold in your territory in 1931 was sold by utilities?

The reporting companies estimate that 70 per cent of all ranges sold in their territory were sold by utilities and that the remaining 30 per cent were sold by other dealers.

What do you estimate these percentages will be in 1932?

With the plans which the utilities have for cooperative advertising and dealer helps, there should be an increase in the percentage sold by dealers in 1932.

Does your compensation plan for salesmen pay them for ranges sold on your lines by dealers on the same basis as ranges sold by the company?

The majority of the companies reporting either have such a plan now in effect or in contemplation.

Opportunity for Dealer

Your committee feels that the practices of the companies as indicated in the answers to the questionnaire above indicate that there is a real opportunity for merchandising profit for the aggressive independent dealer. In practically all instances utilities sell ranges at established list prices.

There's only one way to cook
THANKSGIVING TURKEY....
Electrically!
Would you have your Thanksgiving turkey EXTRA tender and EXTRA flavorful? Then cook it in the oven of an electric range. This modern way of cooking IMPROVES the natural flavor of every meat and vegetable.
And electric cooking SAVES YOU MONEY! There is a natural shrinkage through evaporation when the heat of your oven roasts any kind of meat. To get 9 lbs. of COOKED turkey you must place a 12-lb. UNCOOKED bird in your electric oven. But if you use fuel cookery the evaporation is far more and you must use a 17-lb. UNCOOKED turkey to get the same 9 lbs. of COOKED meat.
These are official N. E. L. A. figures. At 35c a pound you must pay $1.75 extra to get the same amount of COOKED TURKEY, if you use fuel cookery. By cooking electrically YOU SAVE THAT $1.75. And it costs only 51/2c for the electricity needed for the roasting.
The exact amount of shrinkage varies somewhat with every type of meat. But you can always buy 30% to 50% less when you cook electrically. Over a year's time that's quite a saving.
See the following approved electric ranges —sold by leading stores—on easy terms
ESTATE RANGES
Cole Bros. Furniture Co.
Edwards Furniture Co.
Gill, Wortman & Ziring
STANDARD RANGES
Geyers Furniture Co.
WESTINGHOUSE RANGES
Portland General Electric Co.
HOTPOINT RANGES
Portland General Electric Co.
UNIVERSAL RANGES
Watson-Stiff Furniture Co.
Alberta Furniture Co.
M. E. Cole Furniture Co.
L. & H. RANGES
Powers Furniture Co.
MONARCH RANGES
Henry Jenning & Sons
New Low Prices and Easy Terms
PORTLAND GENERAL ELECTRIC CO.
LIGHT PEPCO POWER
ELECTRIC BUILDING
ALDER AT BROADWAY

Fig. 2—Another cooperative range advertisement which lists cooperating dealers carrying standard makes of ranges

As indicated by the answer to the last question, the utilities are vitally interested in the load which will result from dealer range sales, to the extent that most companies recognize this load in their compensation plan for their own salesmen.

Practically every utility in this section has done considerable promotional advertising during the past year. Samples of such ads are attached. Your committee recommends that utilities continue with such cooperative advertising. It is suggested that independent dealers be advised of the periods in which the utility plans to campaign electric ranges. In this way the independent dealer can tie-in with this advertising at a time when he will receive the most from the advertising and promotional work done by the utility.

It is believed that some arrangement whereby the electric utility can offer the services of its range service department to prospective range dealers would be helpful in encouraging them in this business.

Utilities can be helpful to independent dealers just starting in the range business by furnishing them information on operating costs, rates, installation costs, and other semi-technical knowledge which the independent dealer will need in the range business.

Your committee would like to urge that all utilities invite other independent electric range dealers to display ranges at cooking schools held by the utility.

While we have enumerated above several ways in which the utility can help make the independent dealer a real factor in the distribution of electric ranges, the helpfulness of each suggestion mentioned will depend almost entirely on whether or not the utility, by its actions and practices, has secured the confidence of the independent dealer. Mutual confidence is essential to any cooperative program and it is the opinion of your committee that building load through range sales is a cooperative endeavor. Utilities are urged to make more frequent contacts with all independent range dealers and to make sure that these dealers understand the motives, practices and future plans of the utilities.

A joint meeting of the electric range manufacturers, distributors and utility sales managers was held following the afternoon commercial session in the Northwest midwinter conference. The real reason for such a meeting was to enable all in attendance to become more familiar with the policies of the manufacturers and utilities. Future meetings of this character are scheduled.

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*Water Heating**

AS THIS report is part of the merchandising bureau program, the committee has passed over the engineering problems. Sufficient information is available for any company to start on a successful water heating program. Such sources as (a) the recently published N.E.L.A. water heating report, (b) manufacturers' data, (c) local field experience, (d) local laboratory tests, furnish a rich background of facts on which to base the future policy. It is felt that this report should summarize successful practice of member companies in securing electric water heating load.

The 1932 load-building plans of all companies have stressed dealer cooperation. Special emphasis is

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*Report of the water heating committee, merchandising bureau, Commercial Section, Burton A. Hall, Pacific Power & Light Co., chairman.
Idaho Power Co.: J. B. McLain.
Puget Sound Power & Light Co.: George T. Quinan.
Utah Power & Light Co.: H. M. Ferguson.
The Washington Water Power Co.: Lewis A. Lewis.

placed on the development of dealer outlets for the sale of electric ranges, water heaters and refrigerators. The problem is comparatively simple on ranges and refrigerators with the abundance of manufacturers' dealer helps, national advertising, and manufacturers' representatives contacting dealers as an assistance in securing business. Quite a different situation is met in an attempt to stimulate dealer interest in electric water heater sales. These are complicated with certain engineering requirements, such as size, location of tank, etc., local rate restrictions, small dollar volume for each unit sale, comparatively high installation cost, which cause the average dealer to concentrate his sales effort on merchandise easier sold.

It is essential at this time that dealers be trained and encouraged in the sale of electric water heater service. Under the new cooperative plans, the percentage of ranges sold by dealers will, undoubtedly, increase. Unless water heater service is sold with each range, the normal progress of both range and water heater sales will lag. There should be a very close relationship between range, water heater and refrigerator sales. The idea of an all-electric kitchen is the desire of every modern housewife. Dealers who capitalize on this popular demand, will find their volume growing and the profits from their electrical department most encouraging. The water heater policy of all utilities should be as simple as is consistent with good practice. Stripped of all non-essentials, the sale will be much easier for the dealer and the idea much more quickly accepted by the prospect.

The keynote of all promotional sales effort should be the type of service rendered. Advertising, direct-mail literature and all sales contact must be built on the value of the electric service, rather than the sale of equipment or the comparative cost of this service with the cost of competitive fuels. Adequate hot water is as essential to the health and comfort of the modern home as house heat. It has been the experience of many utilities that, in giving an automatic, continuous source of hot water, they have successfully competed for business in competition with much cheaper fuels. The convenience, safety and cleanliness of automatic electric water heating far outweighs the resistance to higher first cost and slightly higher monthly charge.

The preliminary work of selling electric water heater service over competitive methods may be started by an aggressive campaign with architects, builders and plumbers. Home builders are readily influenced by the recommendations of these men, and their active cooperation is invaluable. On older installations, the local plumber is usually the first to be called on for suggestions. A plan enlisting the support of plumbers must be quite remunerative to him, to offset the profit he anticipates in the labor and material of installing furnace and stove coils. The price at which the utility sells its complete installation should be high enough to allow an attractive margin for the plumber. Special effort should be made to have all architects, builders and plumbers use an approved type of electric water heater in their own homes.

Another valuable method of accelerating the rate of acceptance of electricity for water heating is through a high saturation of company employee users. The intelligent support of employees' wives at bridge parties, socials and clubs, etc., often does more to originate a sale than newspaper advertising, floor displays or even the efforts of a specialized sales department.

"Use the User" campaigns have been successful in selling many new electric services. This method is well worth the attention of utilities endeavoring to increase their water heating load. After a few months' use, old installations may become inadequate and unsatisfactory, with the increased use of hot water due to habits formed by its easy accessibility. A careful check of all old installations should be one of the first steps in a new program and should be repeated at intervals of every two or three years. A partially satisfied or dissatisfied user may be the concealed objection in the mind of a neighboring prospect.

Water heating is still in a formative period with many utilities. There are yet widely varying opinions among authorities as to the desirability of the water heating load, the tariff best adapted to secure the volume of business on a profitable return and the type of service to feature. There is, however, a noticeable tendency for agreement on many of the fundamentals, which is making it profitable for equipment manufacturers to enter the field with their engineering research and trained sales specialists. As the volume of business becomes more attractive, the number of sales outlets and the intensity of sales effort on electric water heaters will increase. Progressive utilities will establish a water heater policy conducive to profitable dealer cooperation and thereby insure the permanent development of profitable domestic load building.

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*General Merchandising**

YOUR committee, in considering the subjects of greatest value for this report, has reviewed the reports of the merchandising committee for past years, with the thought that back sights are often a valuable guide to future activities. Although the reports submitted by the merchandising committee in past years have covered many individual phases of the utility merchandising problems, there was consideration given each year to some major subjects which carried through, common to all years. In some of these reports, there seems to have been some question as to the responsibilities or problems of the merchandising committee, feeling that it should not overlap with the range, refrigeration and water heating committees. For this reason, no doubt, major consideration in some years' reports has been limited to small appliances.

The committee this year has assumed that it should be concerned with broader aspects of the merchandising situation, such as policy, plans, methods, etc., which, although common and related to all items in merchandising, are not peculiar to any special or single appliance. The principal subjects to receive consideration by the merchandising committee in all reports from year to year were:

1. The need of organized planning
2. All-employee selling
3. Salesmen training.

Very careful and capable consideration has been given by some of the member companies, at least, to setting-up a comprehensive yearly outline of proposed merchandising activities and accomplishments. While

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*Report of the general merchandising committee, merchandising bureau, Commercial Section, L. W. Brainard, Idaho Power Co., chairman.
The California Oregon Power Co.: Glenn L. Jackson.
Montana Power Co.: John C. Ryan.
Pacific Power & Light Co.: V. H. Moon.
Portland General Electric Co.: A. C. McMicken.
Puget Sound Power & Light Co.: R. W. Clark.
Utah Power & Light Co.: R. M. Bleak.
The Washington Water Power Co.: R. B. McElroy.

a comparative report of results by companies has not been considered, it is a safe prediction that such a report, if available, would show that a well-planned program is a material aid to satisfactory accomplishments. A detailed and comprehensive plan would, no doubt, not be so essential to a strictly merchandising organization in which other phases of utility business are not a consideration, but where it is expected that district managers, accounting employees and service men will keep the interest of merchandising in mind and give this activity support as they carry on their own specialized responsibilities, the value of an outline of proposed activity, set up in a clear and concise manner and in convenient form, is readily apparent.

An important factor in all sales planning has been all-employee selling, as is apparent from the consideration given this subject in the report of the merchandising committee each year. This has been a valued source of merchandise sales and consequent load-building for all utilities where such activity has been properly promoted and urged. This is particularly true in the smaller towns and rural territory, where sales possibilities do not warrant one or more full-time salesmen.

Consideration of dealer cooperation has had a material influence on the sales plans of most utility companies. Changes in plans because of the dealer situation have varied with territories, depending, no doubt, upon the type of territory served, past sales practices and the number and activity of dealers in the territory. This committee has not attempted to deal with the dealer situation, as such. Rearrangement and adjustment of sales plans and activity to meet existing conditions has been, and no doubt will be, an important factor in all sales and load-building activities. For this reason, there has been collected from member companies and included in this report a statement of changes in their respective plans and method, particularly as to changes in their compensation scheme and advertising. From a review of these, and copies of company plans issued in printed form, some of which have been reproduced or described in the trade journals, revisions to meet the changing conditions are quite evident.

The titles of such published outlines have been changed from "Sales Plans," "Sales Activity Outline," or some similar designation used in past years, to a wording more in keeping with and more inclusive of dealer activities, such as, "Development Program," "Dealer-Utility Cooperative Business Building Plan," and other titles of this same nature. These plans are also set up in some cases in such language and in such a way that a copy may be presented to all dealers in the company's operating territory. It is also quite general in these outlines and policy statements that utility salesmen are referred to as "load-building representatives," "terrotorial representatives," or some other designation of like character, avoiding the detrimental effect in the mind of the dealer of the use of the word "salesman" as a title. Within the profession of salesmanship, the word "salesman" is in good standing and the remark that a man is a real salesman is considered a real compliment. For the designation of this committee and discussion in its reports, the word "salesman" or "salesmanship" is satisfactory, but for publication of utility plans, or in conversing with a customer, this title is not in the interest of good dealer and customer relations, for which reason the designations "territorial representative," "commercial representative" or some similar appropriate title should not only be more pleasing to dealers and customers, but should result in better acceptance of those utility employees to whom these titles refer.

In addition to the statements secured from the member companies, this committee will also undertake to effect an exchange of company copies of commercial outlines between all member companies, and, to facilitate this, it is requested that all companies who have issued or contemplate issuing such an outline forward ten copies to the chairman of this committee, who will promptly reforward them to the commercial executives of member companies.

It would be impossible for a committee of this association to suggest policies or methods for adoption by the member companies, as these must be worked out to the best interests of conditions as they exist in the respective territories, but it is urged that member companies lend their support to this exchange of outlines, sales plans and ideas which will keep all commercial executives informed of the activity of other companies which should be of material benefit in setting up sales and load-building promotional activities.

Another subject which this committee has considered and which has been a part of the merchandising committee's report from year to year, is the matter of salesmen's training. This subject becomes more and more important as sales policies are changed from year to year. As was stated in the foregoing pages of this report, it is important that all utility employees be given a copy and be made familiar with the company's commercial plans and policies. It is especially important that salesmen be properly informed and trained along this line. No matter how carefully a company's plans and policies are worded and printed, with the indorsement of the management, with a view to solving the cooperative dealer situation which is receiving so much attention, the effect will at least be lost, if not detrimental, if the salesman (or any employee, for that matter) does not conduct his operations in accordance and in harmony with the policies after they are set up. For this reason, a full knowledge of the company's plans and policies should be a part of every salesman's, if not every employee's training.

As saturations increase and other interests in the market are bidding for the customer's dollar, the salesman's training in sales methods is becoming more and more important, and it is evident from the report of the merchandising committee in past years that sufficient salesman's training material, or at least proper material, has not been available. It has been urged that consideration be given to this matter.

No doubt the urge of the merchandising committee in past years, together with the request of many commercial managers, has been a considerable factor in providing and making available the course supplied by the national educational committee of the N.E.L.A. Many, if not all, commercial executives and utility managers responsible for domestic load building are familiar with this course, entitled "Electric Service Salesmen." All volumes of this course are now available through the N.E.L.A., and many subscriptions have been placed by salesmen and other utility employees. Some companies have made the offer to their employees who wish to avail themselves of this course, that the course will be paid for in part by the company. The purchase amount is deducted from the employee's monthly pay check in small amounts each month until paid for, with the agreement that, upon satisfactory completion of the course, one-half of the purchase price will be returned to the employee by his company. It is felt by the companies making this

offer that it is a worth-while investment and that the beneficial results accruing to the company will be well worth the money.

It is appreciated by this committee that company policies as to sales plans and methods, dealer cooperation and salesman's training, depend upon and must be in keeping with conditions in respective territories, for which reason the committee suggests an interchange of sales outlines, policies and promotional material, for what value it may be to those receiving it, knowing that ideas and suggestions are always welcomed by the commercial executive.

Hoping to be of service in facilitating the exchange of ideas, sales promotional material and policies, the following recommendations are submitted:

1. That all companies issue an annual statement of sales plans and policies.

2. That a copy of such plans and policies be presented to each and every employee, and that it be mandatory that all employees read and familiarize themselves with such plans, thereby making it possible for all employees to continue their selling efforts without violating company policies and jeopardizing good dealer relations.

3. That all member companies forward to the chairman of this committee such material as may be of value and available for exchange between member companies.

4. That the N.E.L.A. course, "Electric Service Salesmanship" be made available to all utility employees, particularly salesmen, on a liberal payment plan. It is felt certain that any portion of the expense absorbed by the company may be considered a good investment, from which a profit will be realized.

One other subject of material interest in merchandising, and consequently to this committee, and a major factor in load building, is the national activity set up by the national refrigeration bureau and the national range council. These will, no doubt, be covered by the refrigeration and range committees and special representatives of the national organizations, for which reason this committee only points to their importance as related to merchandising and load-building activities, and urges that they enjoy the maximum support of all utility commercial departments.

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*An Approach to a Market Analysis**

By G. C. TENNEY

EXPERIENCE of the past two years has focused attention of the electrical industry on the domestic market. People must eat, cook, keep clean, have lights, radio, etc. The logic of this contention is shown by the following figures. Domestic consumption increased 8 per cent, while industrial consumption dropped 30 per cent last year. The net loss in kilowatt-hours was only 4 per cent with an actual gain in gross and net income. This combination of circumstances will continue to hold the attention of the industry on the domestic field.

In the meantime, factors have developed to cloud this picture. Retail merchants, with volume down, have suddenly grasped the theory that power company merchandising is a usurpation of their legitimate rights, is unfair, illegal and must be stopped. Unfortunately, there have been instances of power company merchandising sufficiently vicious to arouse this dormant trade antagonism and to justify the criticisms leveled at them.

Remarks to follow are based on the premise that power companies are vitally and necessarily interested in developing this domestic market; while certain groups of retailers, with surreptitious backing of their supplying wholesalers and manufacturers, are determined to restrict power company participation in the actual sale of electrical appliances to an absolute minimum. It is with this problem that the industry's commercial men are most concerned today, and rightly, since their own jobs are at stake.

We in the publishing business come in contact with all groups in the industry, from the most radical merchandiser, who insists that municipal ownership is the only answer, to the chief executive of a utility who is seriously considering stopping all merchandising activity because of the loud vocal effusions of the minority group represented by the radical element just referred to. From all of these contacts, we have developed a few constructive suggestions which are offered for what they are worth.

As a fundamental premise, we contend that the development of the domestic market is an industry sales job. If we agree on this contention, then there are a few basic principles to which due regard must be given. The initial step is the consideration of the market. Forgetting the means to be employed, we are primarily interested in the ends to be served. We must determine who must be sold and what must be sold. It is our belief that when this is done, the utilities will be armed with a story that will overcome objections to their own sales activities and which will make of the entire industry an organized, educated sales force with individual self-interest in bringing about complete electrification of the home.

Time does not permit a detailed analysis of the entire procedure we have in mind. We can only sketch the outline, leaving to each one of you the problem of filling in the details to fit your own particular case.

I am assuming that I am a commercial manager of a property with 50,000 residential customers located in the Northwest. What does this number of meters mean in potential market? One hundred per cent electrified, these homes would represent $1,500 each in appliances, a connected load of 22 kw. each, with an average maximum demand of 7 kw. each, without considering diversity, and an annual consumption of 6,800 kw.-hr. each. In terms of the total market, the figures are staggering. The appliance volume of interest to the trade is 75 millions, and annual consumption, which is my primary interest, is 340,000,000 kw.-hr.

But these homes are already partially electrified. From actual surveys, we find that 20 per cent have ranges, 12 per cent water heaters, 12 per cent refrigerators, 40 per cent washers, 1 per cent ironers, 35 per cent vacuum cleaners, and so on down the line of appliances. We know, further, that approximately 20 to 30 per cent are minimum consumers, whose income prohibits the purchase of anything but bare necessities. We take these out of our potential market, reducing the total from 50,000 to 40,000. But we will come back to them later, for there are services to be sold to them to increase their value to my company.

What range saturation may we reasonably expect on our lines? Every one cooks. That's one clue. Mr. Brainard in Idaho has sold 50 per cent of his customers ranges. Our ultimate market ought to be 70 per cent saturation. By simple arithmetic, we see that our lines offer an ultimate market exclusive of replacements of 25,000 ranges valued at $3,750,000. Every home needs hot water, hence, every time we sell a range, we create a water heater prospect. Thus we can sell 29,000 water heaters (the present saturation is only 12 per

* Part of a talk presented at Commercial Section meeting, Portland, Ore., Feb. 19, 1932, as part of merchandising bureau program.

cent) valued at $1,450,000. Fifty per cent of our customers use ice part of the year. Only 12 per cent have electric refrigerators. Every ice user is a prospect. As a result of this reasoning, we have a refrigerator market of 20,000 units or a volume of $5,000,000.

We take the appliances item by item and, when the total column is added up, we find that the potential market for the electrical industry in the homes in my territory is about $22,500,000 in appliances alone. Furthermore, we have not taken into consideration air conditioning, sunlamps, nor a host of new services just over the threshold.

Will the electrical trade in my territory still be antagonistic when I tell them the story of the $22,500,000 market; show that its capture is a fight against all other industries selling the home; that we can only play a small part in the actual appliance sales; that securing this business means lower rates to our customers, which in turn means even greater market possibilities; that we are going to spend money in sales promotion that will redound to their benefit? You might ask, "Will the dealer respond to this type of argument?" Well, my title is sales manager, and, if I'm a salesman, I can sell him.

Of course, along with this story there must be a policy that will prove to the dealer that my company is vitally interested in his participation in this market development program. You men are sufficiently familiar with the situation to make elaboration of this policy unnnecessary. Here are the things my policy would cover:

1. My salesmen would not be so compensated that their livelihood depended upon ruthless competition with the retail merchants.

2. Knowing that the dealer is most inflamed when he is undersold by a large competitor, I would not give premiums, make excessive trade-in allowances, or special offers of any kind, or better or longer terms or discounts because all of these are only different names for the same thing—price-cutting.

3. I would maintain the highest standards of quality and price with the merchandise I carried, because example is the best precept.

4. I would not offer doles, subsidies, nor make promises that I did not expect to keep.

Initially the statement was made that this domestic market development program was an industry sales job. So far we have only considered the retailers, probably because their point of view is most pressing at the moment.

There is an angle to our market development story that has been largely overlooked, namely, the interesting of that large group in the industry whose primary concern is the manufacture and supply of the sinews of our utilities—the wire, the insulators, transformers, poles, meters, switches, generators, and the like. Whether they know it or not, they have a definite self-interest in our program.

Did you ever stop to realize that every time you sell an electric range, a market is created for material and apparatus to the extent of $117? N.E.M.A. has figured out that each electric range sold means $9 in switches, $20 in wire and wiring supplies, $7.50 in meters and instruments, $14.40 in transformers, $6.10 in distribution materials, $20 in substation equipment, and $40 in generating equipment. A California utility has figured that each new kilowatt of residential demand creates $51 in business for the suppliers and manufacturers of this type of apparatus. If again I am a good sales manager, can't I interest these people in helping to develop the domestic market?

This same story should arouse the enthusiasm and interest of the engineering department and the construction forces of my own company. To them it means more work, more planning and designing, and building the system facilities to serve the load added. Thus we build our industry sales force.

There is another phase of this market program which will interest the contracting branch of the industry. Each new range user means a wiring job which will average $35, or a total wiring market of $875,000. In addition, despite the fact that we must look largely to existing consumers for our new load, there will be some new consumers, some new homes added to the lines of my company. My commercial program would include sales activity to see that these homes were adequately wired, so that my sales force, or that of the dealers, would not have added sales resistance in the form of inadequate wiring to meet in selling the $1,500 worth of appliances for which this new homeowner is a prospect. Not having figures available for this territory, we can only cite some from California to prove this point. In that state the average home is wired with eighteen outlets, at a price of $75 to the electrical contractor. An adequate job called Red Seal in California, calls for 33 outlets, including range, and brings the contractor $290. Figures show that the average Red Seal home, which is just another way of saying adequately wired home, consumes 3,500 kw.-hr. The home as usually wired for lights and appliances consumes only 491 kw.-hr. The additional 3,000 kw.-hr. per year is my justification for including adequate wiring in my sales program.

Thus would I build my domestic market development program.

POWER BUREAU[1]

*Are Small Industrial Heating Loads of Value to the Central Station**

[1] Executive committee: B. P. Baily, Pacific Power & Light Co., chairman.

* Report of the industrial heating committee, power bureau, Commercial Section, J. D. Frantz, General Electric Co., chairman.
Eastern Oregon Light & Power Co.: O. D. Lanning.
Idaho Power Co.: J. B. McLain.
Mountain States Power Co.: John B. Cashin.
Northwestern Electric Co.: A. K. Gaylord.
Portland General Electric Co.: A. B. Chambers.
Puget Sound Power & Light Co.: H. B. Batchelor.
Utah Power & Light Co.: G. B. Walker.
The Washington Water Power Co.: A. K. Wagoner.
Westinghouse Electric & Manufacturing Co.: R. C. Cooper.

YOUR industrial electric heating committee welcomes this opportunity to present its tentative program for the ensuing year. Past committees have reported on practically every activity relating to industrial heating and many of them have had a pronounced influence on this important field.

Your committee feels that its problem is not to spend time and energy trying to sell large installations, unless, however, they have at least become possibilities; but instead, to devote our endeavors to the smaller installations. It is in this latter field that we can develop. Large installations will present themselves to us, but the small jobs may lie hidden for years unless we have the incentive to discover and sell them.

But how much can we afford to spend in man-hours to electrify the small installation? There is undoubt-

edly a great deal of time wasted on small jobs. Some of these never materialize; others, even though installed, do not stay on the line long enough or consume sufficient power to have warranted their installation. As an example, would it be profitable to spend three days in securing a load of 1 kw. in strip heaters? This resolves itself into an expression which we hope to solve, namely:

How many man-hours can we profitably expend for each kilowatt-hour of consumed power, or in a simplified form:

X man-hours per kilowatt-hour.

The unknown "X" in this expression contains many variables, of which the most important are:

1. The average rate of revenue
2. Per cent of expected revenue the central station would be willing to spend to secure this load
3. Chances of securing business
4. The equivalent value of a man-hour in dollars.

The term, "chances of securing the business," should receive consideration. It should not be a percentage of the actual number of jobs which have been worked on, but should take into account both the size of the job and the time spent. In brief, we will assume we have worked on two propositions. On the first, a 5-kw. job, we worked 10 hours; on the second, a 10-kw. job, we worked 10 hours also. The first makes 50 hour-kilowatts, and the second, 100 hour-kilowatts. Their sum makes 150 hour-kilowatts, or should we have been successful in securing the first job only, our result would be 33⅓ per cent. The second job only would give us a result of 66⅔ per cent. We believe that the last ten jobs on which we have worked will give us a fair and representative value for this term.

Let us assume that:

1. The average rate of revenue is 2c. per kw.-hr.
2. The central station is willing to spend 10 per cent of the revenue to secure the load.
3. The chance of securing business is 50 per cent.
4. A man-hour is equivalent to 75c.

Our expression then becomes:

0.00133 man-hours per kilowatt-hour, or
1.33 man-hours per 1,000 kilowatt-hours, or
2 man-days per 10,000 kilowatt-hours, or
3 man-weeks per 100,000 kilowatt-hours.

Please understand that these assumed figures are used merely to show the method of arriving at what we hope to attain.

The item of promotive work has not been considered, although it is very important. There is no reason why it could not be inserted in this expression to suit individual conditions.

Should we be able to arrive at a fair value for "X" in this expression, we will then be able to determine quickly whether or not a certain contemplated load would be worth securing—or better yet, we will know how many man-hours we can devote to the securing of this load. To determine this in any particular case it will be necessary to multiply the value of "X" by the total kilowatt-hours we expect the installation to consume. We realize that this total of kilowatt-hours cannot be definitely determined, but past installations of a similar nature will give us a basis on which to make our assumptions.

We expect this expression to show that far too few, rather than too many, man-hours have been devoted to the securing of small industrial heating loads. That small heating loads are available is well evidenced by the record of one of the Portland central stations. This company has made many desirable installations, a few of which are:

No.	Nature of Load	Kw.
1	Fuel oil heating for pumping (immersion units)	45
1	Molasses heating (strip heaters)	4
1	Steam cabinet heater (strip heater)	3
7	Electric hot beds (soil heating cable)average, each	1
1	Lace curtain dryer (circulating air heater)	3
7	Steam boilers for clothes pressing (immersion units) average, each	10
1	Tar dipping process (immersion units)	75
1	Dental plate process (immersion units)	25
1	Baseboard heater (air heater)	5
1	Tar process mixer (strip heater)	15
1	Grease washing vat (immersion units)	5
2	Branding irons, each	1

It has been estimated that as a revenue builder a 1-kw. industrial heating load, operating 8 hours per day, is equal to the average domestic range. Now consider the cost of connecting these respective loads to our lines. Except where a number of ranges can be grouped together, it will require a 5-kva. transformer, a new watthour meter, new copper from the pole to the house and expensive rewiring within the house, while the one 1-kva. heating load can usually be connected to an already existing circuit in the industrial plant by using a switch and a few feet of conduit and wire. The range shows an advantage or a high gross profit, but compare the overhead expense of an elaborate show room with the warehouse space devoted to industrial heating equipment. Considering these facts and others, we ask, "Is the 1-kw. heating load receiving its due attention?"

We believe that it is not.

Your committee this year expects to have an active member in each of the Northwest companies. Our first objective will be to solve the above expression. Second, to have a three-months' campaign among ourselves, in order to become fully acquainted with what equipment is available and its proper application. By equipment we mean air heaters, water heaters, oil heaters, gluepots, compound pots, soldering irons, metal melting pots, etc. Lastly, a customers' campaign of six months in an effort to build our load with these small units.

The results to be expected are: (1) increased revenue; (2) and probably more important, our customers will acquire the habit of coming to us for advice and assistance on all heating propositions. This will place us in a more favorable position when a large proposition presents itself and other forms of energy are to be considered.

---

*Commercial Cooking**

DURING the past year, the installation of electrical equipment has, of course, fallen off in about the same proportion as other commodities. There has been little or no building of hotels, restaurants, or hospitals and little expansion of these or other institutions which may be considered in the commercial cooking business. This has naturally cut down the normal growth of the load expected from these sources.

The equipment which has been sold has, as a rule, been connected to the lines of the public service companies only after keen competition with equipment using other fuels. This competition has, or at least

* Report of the commercial cooking committee, power bureau, Commercial Section, P. E. Stowell, Dohrmann Hotel Supply Co., chairman.

should have, given us all lessons in our own merchandise, sales arguments we had not thought necessary to use before and a persistence in presenting our lines that in flush times was not considered necessary.

In some territories it is felt that the saturation point is within sight on household equipment and that the central station must look in other directions for a profitable increase in demand. There is no doubt that the commercial cooking field has been somewhat neglected in many parts of the Northwest. In some localities, this has resulted from half hearted work or from concentrating on other lines, and at other points from unfavorable rates as compared with cheaper fuels.

The restaurant, hotel and hospital are, as a rule, desirable loads, a great deal of their work of food preparation for the day being offpeak, that is, occurring between 8 a.m. and 2 p.m. I believe that rates for this class of business have in a large measure been adjusted during the past few years, so that we may now consider these rates as fairly competitive with other fuels, all things being taken into consideration.

How to increase sales to these desirable institutions is our problem. There has been a change in merchandising methods of electrical equipment in the past few years, and the pioneering days are over. It is no longer felt necessary for the manufacturer to send highly trained technical salesmen to meet and win over reluctant or disinterested prospects. This pioneering stage has been a necessary part in presenting every new idea to the public. The retail merchant has always taken and will continue to take the position that it is not his business to pioneer an article, but that he will handle it in a retail way when the demand is assured. Pioneering new items is done at tremendous cost and unless these lines become staple and the volume fairly great, it is wasted effort from a financial standpoint.

The promotion stage is now over and electrical merchandise is considered about as staple as any other commodity. The public has become educated to the fact that there is nothing mysterious in electrical cooking equipment. Retail merchants carry complete lines of electrical merchandise. Why, even the drug stores carry electrical cooking equipment, along with auto tires, jewelry, sandwiches and other druggist's items.

What I have said applies to electrical equipment for the home, but the same degree of progress has not been made in the commercial cooking line. There are a number of reasons for this, which must be given careful consideration if increased sales in this highly desirable branch of electrical merchandising are to be attained.

The type of person generally engaged in the hotel or restaurant business is not as easily convinced as the average housewife. Her problem is convenience and cleanliness, with fuel cost the last consideration. His is cost of operation or cost per meal. Many in authority in these fields are foreigners who are bound by the many traditions of their calling, their early environment or by pure prejudice.

The average proprietor of the public eating place knows little of electrical terms and cares less, and it is a mistake to talk to him in the (to him) jargon of the scientist. They may do in discussing the Einstein theory, "yes," but for soups, "no." His ideas of electrical appliances are based largely on the little hickeys sold in the average store—curling irons, corn poppers, toasters and flat irons. He does not associate these things with heavy ranges, broilers, ovens and deep fat fryers required in his business, and his experience with the small household article has made him skeptical as to the adaptability of electricity to his business.

He has an idea, due to the continuous "bla bla" of the politician, who hopes for public ownership so that he may ride into office on a popular war cry, that the rates charged for electrical energy are so extremely high that even to consider electrical cooking is, for him, out of the question.

Not only does the politician instill these ideas, but there is ever being presented before his eyes the hope of natural gas at unnaturally low rates, the gas to be obtained from some local hole in the ground or piped from some far distant field which has billions of feet going to waste, which must be used to cut down economic loss, the distribution cost never being presented. Furthermore, we have the fuel oil people, in favored sections, campaigning for the further use of oil, which is now a drug on the market. They show him paper savings which will pay for his equipment in a few short months and present the alluring prospect to him of living happily ever afterward on the net result.

Now these things all create sales resistance—and this is where the manufacturer feels (and we agree with him) that the dealer in hotel supplies fits into the scheme of things. He can be of assistance to the power companies in placing heavy duty cooking equipment, and in increasing the demand for electrical energy.

In order that there may be no personalities, I will state that others as well as ourselves represent heavy duty manufacturers. The salesmen covering the territory, as a rule, know the restaurant man. We know his problems, his methods of food preparation and what will best fit his peculiar conditions. We know his peculiarities and his prejudices, probably better than the power salesman. We have made studies of what electrical equipment will actually do in the preparation of foods in commercial quantities, and, further, what is serviceable and what is not, in new equipment. We therefore feel that the equipment house is peculiarly fitted to render service to the electrical industry in marketing the product of the manufacturer of equipment and in placing equipment on the lines of the power companies.

The power company, however, must not forget that it has an advantage which it must cultivate. It is a local institution; it is already doing business with the restaurant, hotel or hospital; it has them on its books for light and power and is probably better known to them locally than we are. We must therefore work hand in hand in order to reap the full benefit of our positions in the field.

With this end in view, the Edison General Electric Appliance Company, makers of heavy duty equipment, feels that it is time for it to cease a great deal of its promotion work and devote its time to manufacturing. It has decided to market its output in the western states through the Dohrmann Hotel Supply Company and will close its warehouse at Ontario, California. Stocks of its equipment will be warehoused by the supply company at Los Angeles, San Francisco and Portland, which may be drawn on by the power companies at central station prices as in the past. Salesmen will call on the power companies in all towns and will assist the local offices in any way possible in closing deals for equipment, in digging up new prospects and in working with the consumer to further the sale of heavy duty equipment. With this set-up, you will see that, as I have said before, the hotel equipment house is placed in the position of being a direct aid to the cen-

tral station. We want you to feel that your problems are ours and that we welcome a call for assistance. If you can, at any time, point out where we can give greater service, your suggestion will be acted upon immediately.

In our opinion, the factory's stepping out of the field, and turning the line over to merchandisers, will result in greater activity. The representatives of the factory have not been able to give a full measure of promotion work to the central stations for several reasons, chief among them being the obvious fact that they were not acquainted with the prospective purchaser, and that when the factory representative appeared on the scene, he was regarded with suspicion, as a high power salesman. Aside from this, it was realized that the factory representative did not visit the smaller towns frequently and that even in the larger towns, his time was so limited that he really had no time for intensive work with the consumer. In other words, his time was spent promoting his equipment to the central station in place of to the consumer.

In passing this responsibility on to the supply house, the factory expects us to contact the central station, but the bulk of the work our men are expected to do is with the consumer, either with the power company or direct. This is where the work will do the most good. Therefore, as I have stated before, our men will call on the power company representative on each visit to a town and will either work with such company representative or will work direct. The arrangements for such a method of covering the field in each territory will naturally have to be worked out between the sales department of the power company and the general sales department of our organization. Where this system has been tried out, however, it is felt by those concerned that the results have justified our belief that the place to put our promotion efforts is with the consumer.

As briefly stated, stocks will be carried in Los Angeles, San Francisco and Portland, which will give coast points a far better service on stock than they have previously had. Where freight rates are not favorable, shipments will be made from Chicago. Carrying three separate stocks is, of course, a greater investment, but means more prompt delivery, and the securing of an order, occasionally, which might otherwise be lost. On first thought, some of the power concerns may view with suspicion this delegating a jobber to supersede the direct factory offices, but we can assure you it is done with the idea of promoting better service, more direct work with the consumer, closer cooperation between the equipment salesmen and the power company salesman, and, lastly, with the sole idea in mind of more sales and, for you, a greater load.

I believe this covers the picture for this year of what we hope to accomplish and where the jobber stands in relation to you in the sale of heavy duty equipment. Our interests are mutual; let us go hand in hand through 1932 with the slogan "more and better cooking by electricity."

GENERAL BUREAU

*Customer Relations**

THE customer relations committee is one of the newer committees of this geographic division. In fact, this is the first year for some time that it has been active in this association, although it has been one of the committees of the Commercial National Section for many years.

The committee felt that due to the stress of times, it would not be advisable to hold a committee meeting during this association year, so all work and plans of the committee have been carried on by correspondence. The chairman wishes to express his appreciation to the members of the committee for their efforts in furnishing the data necessary for this report.

The purpose of this committee is to promote good will and improve the relationship between the utility and its customers by formulating and suggesting improved methods for handling customer contacts. The committee's work covers all practices and policies which influence the attitude of the customer toward the company, especially such matters as order procedure, simplification of methods, handling of inquiries and complaints, meter reading, collections and credits, telephone and correspondence communication and other routine that tends to improve our service and make it more pleasing to the user.

The committee recognizes the controversial position it occupies, since customer relations involve all phases of operating company procedure. It of necessity deals with accounting, engineering, merchandising, operating and other subjects handled by various other committees of this association. The committee, for the work of this association year, has endeavored to secure information regarding the practices now in effect in the territory of our individual member companies so that this information can be given to each of these companies with the thought that the exchange of ideas would, no doubt, be beneficial to all.

Reports were received from nine of the larger member companies of the association, together with copies of the forms now in use in connection with the various subjects within the scope of this committee's work.

An exhibit of these forms is appended and a folder containing copies will be furnished to each of the companies who so very kindly furnished the information requested by the committee.

Considerable interest in the subject of customer relations was expressed by all of the reporting companies, and we believe that there is an earnest desire on the part of all concerned to improve, if possible, the present methods of handling customer contacts.

Summary of Questionnaire

A questionnaire was answered also by the reporting companies, and it may be of interest to note some of the points considered.

Only one of the nine companies has any regular procedure for welcoming new customers. This company uses a sticker attached to the initial bill for service.

Five of the nine companies require meter deposits from residential customers unless they have been previously served by the company. The other four investigate the new applicants' credit rating before requiring deposits.

Four of the companies use some form of card at

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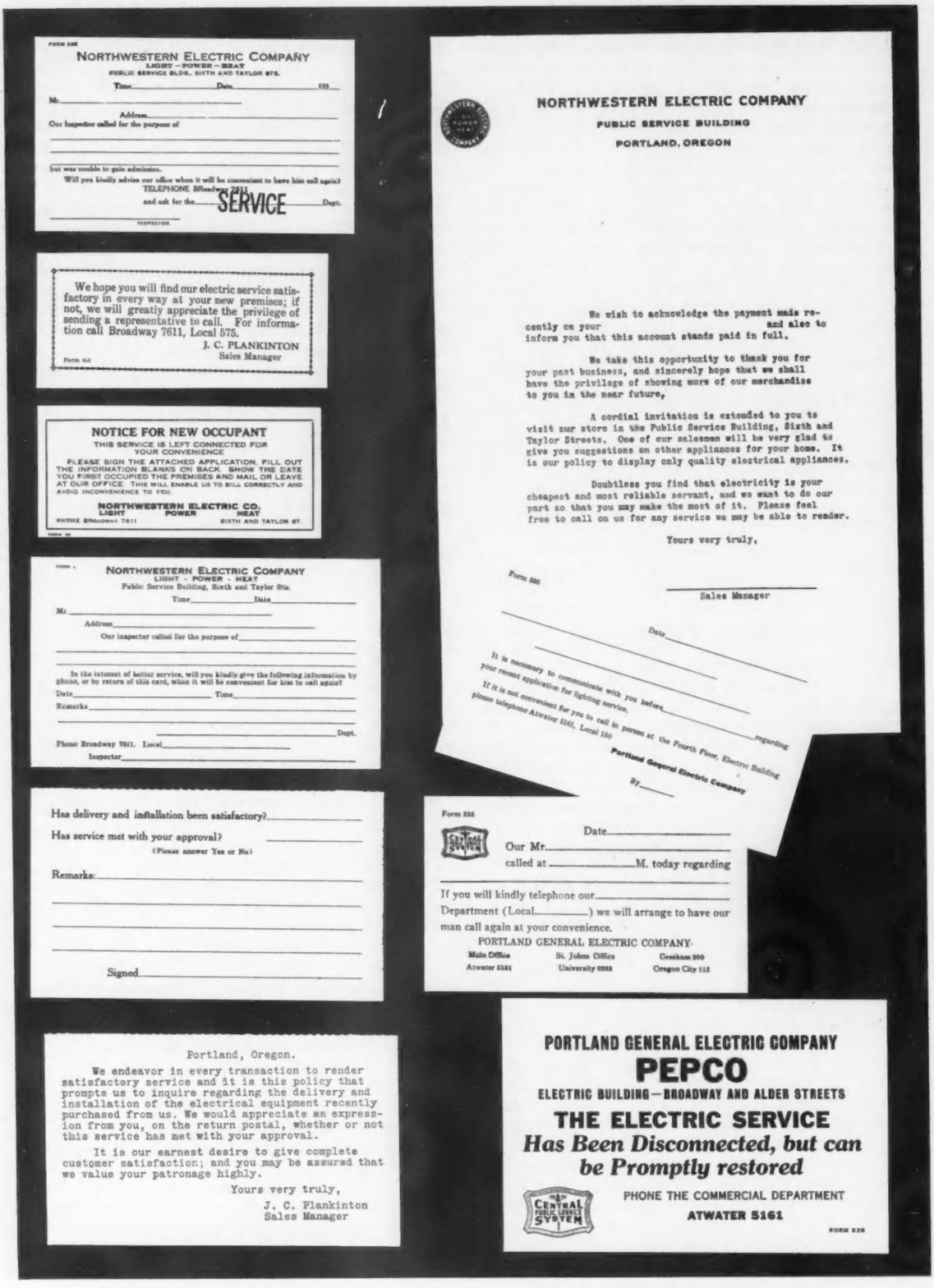
* Report of the customer relations committee, general bureau, Commercial Section, K. M. Robinson, Idaho Power Co., chairman.
The California Oregon Power Co.: C. C. Archibald.
Eastern Oregon Light & Power Co.: J. P. Lottridge.
Montana Power Co.: S. P. Hogan.
Pacific Power & Light Co.: Will T. Neill.
Portland General Electric Co.: E. E. Ullery.
The Washington Water Power Co.: A. H. Wegner.



NORTHWESTERN ELECTRIC COMPANY
LIGHT — POWER — HEAT
PUBLIC SERVICE BLDG., SIXTH AND TAYLOR STS.

Time____ Date____ 193__

Mr.____

Address____

Our inspector called for the purpose of

but was unable to gain admission.

Will you kindly advise our office when it will be convenient to have him call again?

TELEPHONE BRoadway 7611
and ask for the SERVICE Dept.

INSPECTOR

We hope you will find our electric service satisfactory in every way at your new premises; if not, we will greatly appreciate the privilege of sending a representative to call. For information call Broadway 7611, Local 575.

J. C. PLANKINTON
Sales Manager

Form 641

NOTICE FOR NEW OCCUPANT

THIS SERVICE IS LEFT CONNECTED FOR YOUR CONVENIENCE

PLEASE SIGN THE ATTACHED APPLICATION, FILL OUT THE INFORMATION BLANKS ON BACK, SHOW THE DATE YOU FIRST OCCUPIED THE PREMISES AND MAIL OR LEAVE AT OUR OFFICE. THIS WILL ENABLE US TO BILL CORRECTLY AND AVOID INCONVENIENCE TO YOU.

NORTHWESTERN ELECTRIC CO.
LIGHT POWER HEAT
PHONE BROADWAY 7611 SIXTH AND TAYLOR ST.

NORTHWESTERN ELECTRIC COMPANY
LIGHT - POWER - HEAT
Public Service Building, Sixth and Taylor Sts.

Time____ Date____

Mr.____

Address____

Our inspector called for the purpose of____

In the interest of better service, will you kindly give the following information by phone, or by return of this card, when it will be convenient for him to call again?

Date____ Time____

Remarks____

Dept.

Phone Broadway 7611. Local____

Inspector____

Has delivery and installation been satisfactory?____

Has service met with your approval?____
(Please answer Yes or No)

Remarks:____

Signed____

Portland, Oregon.

We endeavor in every transaction to render satisfactory service and it is this policy that prompts us to inquire regarding the delivery and installation of the electrical equipment recently purchased from us. We would appreciate an expression from you, on the return postal, whether or not this service has met with your approval.

It is our earnest desire to give complete customer satisfaction; and you may be assured that we value your patronage highly.

Yours very truly,
J. C. Plankinton
Sales Manager

NORTHWESTERN ELECTRIC COMPANY
PUBLIC SERVICE BUILDING
PORTLAND, OREGON

We wish to acknowledge the payment made recently on your ____ and also to inform you that this account stands paid in full.

We take this opportunity to thank you for your past business, and sincerely hope that we shall have the privilege of showing more of our merchandise to you in the near future.

A cordial invitation is extended to you to visit our store in the Public Service Building, Sixth and Taylor Streets. One of our salesmen will be very glad to give you suggestions on other appliances for your home. It is our policy to display only quality electrical appliances.

Doubtless you find that electricity is your cheapest and most reliable servant, and we want to do our part so that you may make the most of it. Please feel free to call on us for any service we may be able to render.

Yours very truly,

Sales Manager

Form 306

Date____

It is necessary to communicate with you before____ regarding your recent application for lighting service.

If it is not convenient for you to call in person at the Fourth Floor, Electric Building please telephone Atwater 5161, Local 150

Portland General Electric Company

By____

Form 335

CENTRAL PUBLIC UTILITIES SYSTEM

Date____

Our Mr.____

called at ____ M. today regarding

If you will kindly telephone our____

Department (Local____) we will arrange to have our man call again at your convenience.

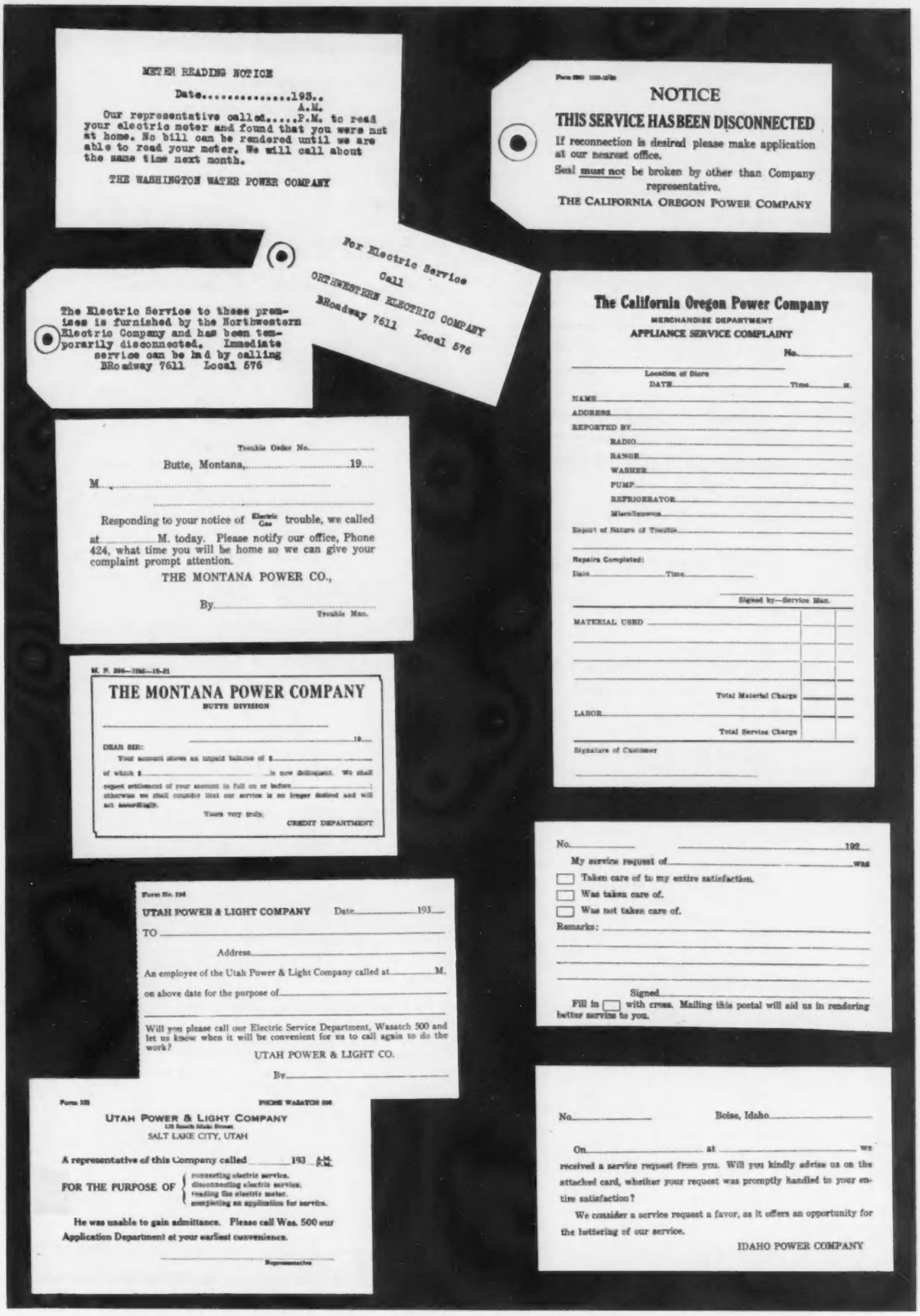
PORTLAND GENERAL ELECTRIC COMPANY

Main Office Atwater 5161 | St. Johns Office University 0393 | Gresham 200 Oregon City 115

PORTLAND GENERAL ELECTRIC COMPANY
PEPCO
ELECTRIC BUILDING—BROADWAY AND ALDER STREETS
THE ELECTRIC SERVICE
Has Been Disconnected, but can be Promptly restored
CENTRAL PUBLIC UTILITIES SYSTEM
PHONE THE COMMERCIAL DEPARTMENT
ATWATER 5161

FORM 336

Courtesy forms in use by member companies of Northwest Electric Light and Power Association



METER READING NOTICE

Date.....193..

A.M.

Our representative called.....P.M. to read your electric meter and found that you were not at home. No bill can be rendered until we are able to read your meter. We will call about the same time next month.

THE WASHINGTON WATER POWER COMPANY

NOTICE

THIS SERVICE HAS BEEN DISCONNECTED

If reconnection is desired please make application at our nearest office.

Seal must not be broken by other than Company representative.

THE CALIFORNIA OREGON POWER COMPANY

The Electric Service to these premises is furnished by the Northwestern Electric Company and has been temporarily disconnected. Immediate service can be had by calling BRoadway 7611 Local 576

For Electric Service Call NORTHWESTERN ELECTRIC COMPANY BRoadway 7611 Local 576

The California Oregon Power Company

MERCHANDISE DEPARTMENT

APPLIANCE SERVICE COMPLAINT

No.....

Location of Store

DATE..... Time..... M.

NAME.....

ADDRESS.....

REPORTED BY.....

RADIO.....

RANGE.....

WASHER.....

PUMP.....

REFRIGERATOR.....

Misc/Remarks.....

Report of Nature of Trouble.....

Repairs Completed:

Date..... Time.....

Signed by—Service Man.

MATERIAL USED

Total Material Charge

LABOR

Total Service Charge

Signature of Customer

Trouble Order No.....

Butte, Montana,.....19....

M.....

Responding to your notice of Electric Gas trouble, we called at.....M. today. Please notify our office, Phone 424, what time you will be home so we can give your complaint prompt attention.

THE MONTANA POWER CO.,

By.....

Trouble Man.

M. P. 394—1246—15-21

THE MONTANA POWER COMPANY

BUTTE DIVISION

.....19....

DEAR SIR:

Your account shows an unpaid balance of $.....

of which $..... is now delinquent. We shall request settlement of your account in full on or before.....; otherwise we shall consider that our service is no longer desired and will act accordingly.

Yours very truly,

CREDIT DEPARTMENT

No.....

.....192...

My service request of.....was

☐ Taken care of to my entire satisfaction.

☐ Was taken care of.

☐ Was not taken care of.

Remarks:.....

Signed.....

Fill in ☐ with cross. Mailing this postal will aid us in rendering better service to you.

Form No. 194

UTAH POWER & LIGHT COMPANY Date.....193...

TO.....

Address.....

An employee of the Utah Power & Light Company called at.....M.

on above date for the purpose of.....

Will you please call our Electric Service Department, Wasatch 500 and let us know when it will be convenient for us to call again to do the work?

UTAH POWER & LIGHT CO.

By.....

Form 333 PHONE WASATCH 500

UTAH POWER & LIGHT COMPANY

135 South Main Street

SALT LAKE CITY, UTAH

A representative of this Company called.....193.....A.M. P.M.

FOR THE PURPOSE OF { connecting electric service. / disconnecting electric service. / reading the electric meter. / completing an application for service.

He was unable to gain admittance. Please call Was. 500 our Application Department at your earliest convenience.

.....

Representative

No.....

Boise, Idaho.....

On..... at ..... we received a service request from you. Will you kindly advise us on the attached card, whether your request was promptly handled to your entire satisfaction?

We consider a service request a favor, as it offers an opportunity for the bettering of our service.

IDAHO POWER COMPANY

Courtesy forms in use by member companies of Northwest Electric Light and Power Association

UTAH POWER & LIGHT COMPANY
KEARNS BUILDING
SALT LAKE CITY, UTAH

We know that the electric ranges which you have recently selected from our store for installation in your home will provide for you a source of satisfaction, and that it will make easier and more convenient the daily task of cooking in your household.

Your patronage is appreciated, and we trust that you will not hesitate to let us know whenever you feel that this appliance is not rendering the service which you think it should.

Sincerely,

Division Manager.

Note: A similar letter is sent for each major appliance sold.

UTAH POWER & LIGHT COMPANY
KEARNS BUILDING
SALT LAKE CITY, UTAH

(Date)

Dear Mrs.:_____:

We take this opportunity of expressing our appreciation for your patronage. We are returning herewith the contract covering the purchase of an Electric _____, as your account was paid in full _____.

We certainly hope the _____ has brought additional convenience and comfort to your home.

Ida Clyde Clark has wonderfully expressed the idea of a home in the following words:

"Home is beautified and sweetened
and harmonized in proportion to
the amount of household drudgery
that is lifted from the shoulders
and mind of the wife and mother."

It will be our pleasure to assist you in making selection of electrical devices to accomplish this end.

Yours very truly,

UTAH POWER & LIGHT COMPANY

Division Sales Sup't.

UTAH POWER & LIGHT COMPANY
KEARNS BUILDING
SALT LAKE CITY, UTAH

These are truly very unusual times which require cooperation of everyone.

We have several hundred customers who are not in a position to pay their regular light bills when due. Many are out of work, some have had considerable sickness, all have had unusual conditions which prevent them from paying on time, but they have shown a splendid spirit of cooperation by calling at our office to talk over their particular circumstances.

We are especially interested in helping you if you cannot pay your bill now.

It is expensive for us to have collectors call on you as they have been doing, therefore, if you will call on our Mr. Featherstone, at our office during the next two days he can, we are sure, help you.

Sincerely yours,
UTAH POWER AND LIGHT COMPANY
Collection Department

F:DL

UTAH POWER & LIGHT COMPANY
KEARNS BUILDING
SALT LAKE CITY, UTAH

Will you act as Judge?

Will you give us your decision on a delinquent account which needs analyzing?

A customer is owing a past due electric bill.

The Utah Power & Light Company has willingly granted credit by furnishing service after the bill was due.

The Company has gone to the expense of sending a representative on several occasions to your home to collect the account or arrange for settlement.

The Company is personally interested in helping the customer when necessary.

The customer has not responded to our request for payment nor has he called to arrange for extension of time in case he cannot pay now.

Is the customer intending to cooperate with the Company. You are the judge! Your remittance or a call in person tomorrow means "Yes".

Sincerely yours,
UTAH POWER AND LIGHT COMPANY
Collection Department

F:DL

Courtesy forms in use by member companies of Northwest Electric Light and Power Association

No.....Idaho .....193....

We would appreciate knowing if your electric.....

is entirely satisfactory and if there is anything we can do to make your electric service more efficient.

IDAHO POWER COMPANY

My.....purchased from you

( ) is entirely satisfactory.
( ) is giving fair results.
( ) is not satisfactory.

Remarks:.....

.....

.....

Signed.....

Please fill in above space ( ) with cross. Mailing this postal will aid us in rendering better service to you.

COURTESY CARD

Satisfactory business relations are valuable both to customer and company. In recognition thereof this card is issued.

.....19....

TO IDAHO POWER COMPANY IN IDAHO AND OREGON:

The bearer of this card, MR. .....

whose signature is affixed, has been a valued customer of our company. Our mutual relations have been entirely satisfactory, and we are very pleased to recommend him to the courtesies of this company where service may be requested.

IDAHO POWER COMPANY

By.....

Bearer's Signature.....

The office of Idaho Power Company receiving this card will please keep for reference

0256—1M—11-29

IDAHO POWER COMPANY

TELEPHONE

To the occupant of the property located at.....

.....

We called today, To.....

.....

but were unable to gain admittance. Kindly notify us when you will be at home.

Date..... Time.....

Signed.....

FORM 501-256-10-29

IDAHO POWER COMPANY

Instructions to Employees

This card is to be used in each instance when in answering a call from a customer you are unable to gain admittance, and is to be left under the door of the customer's premises so that it will be found on his return.

The employee making the call will sign the card and fill in the blank spaces with the address of the customer, the purpose for which the call is made, the date and the hour.

COURTESY CARD

CONDITIONS AND PURPOSES OF ISSUANCE (FOR INFORMATION OF APPLICATION AND CREDIT MEN)

To be issued by Idaho Power Company in Idaho and Oregon.

CONDITIONS

To be issued only to domestic customers in good credit standing when leaving a city. *(Prompt payment of all obligations for a minimum period of six months necessary.)*

Card to be issued with thought in mind that many utilities to which it is presented by holder will use it as basis of credit.

Card to interfere in no way with the rules and regulations of utility companies.

PURPOSE

Primarily to give the customer recognition of his good standing and to create in him an appreciation for the service and courtesy of the utility.

To remind the customer that good service is mutual and encourage future performance on his part.

To pass on to other utilities the good record of a customer.

To create incentive for a customer to pay all utility accounts before leaving a city.

To make possible elimination of demand for deposits from new customers when deposits are unnecessary.

APPLICATION

Card to be given or mailed customer only after payment of final bills.

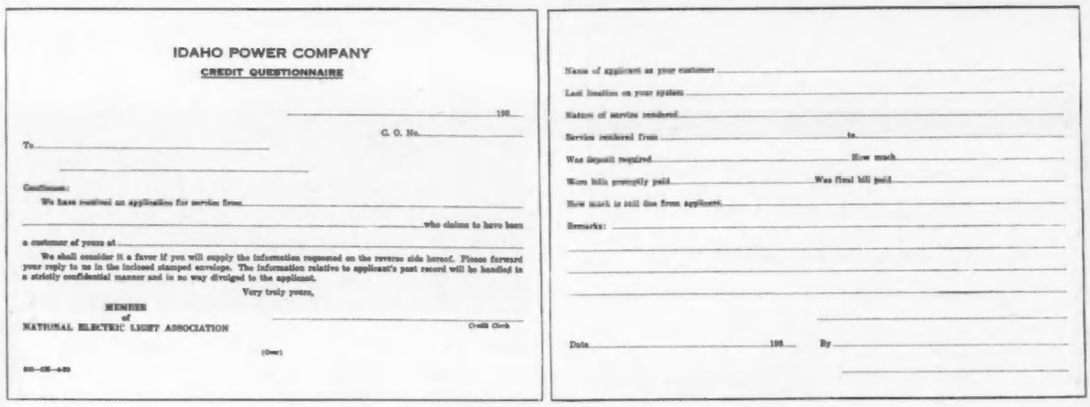
To prevent possible use for credit purposes, card to be taken up by office to which it is presented.

For it to have a wide acceptance necessarily means that it must be issued under the same circumstances in all cases, as outlined above.

The success of this courtesy card depends on the care in issuance and the reception of the customer upon its presentation.

Please preserve and keep displayed in convenient location for employees only.

Courtesy forms in use by member companies of Northwest Electric Light and Power Association



IDAHO POWER COMPANY

CREDIT QUESTIONNAIRE

_____ 193__

G. O. No._____

To_____

_____

Gentlemen:

We have received an application for service from_____

_____who claims to have been

a customer of yours at_____

We shall consider it a favor if you will supply the information requested on the reverse side hereof. Please forward your reply to us in the inclosed stamped envelope. The information relative to applicant's past record will be handled in a strictly confidential manner and in no way divulged to the applicant.

Very truly yours,

_____

Credit Clerk

MEMBER of NATIONAL ELECTRIC LIGHT ASSOCIATION

(Over)

60—GE—449

Name of applicant as your customer_____

Last location on your system_____

Nature of service rendered_____

Service rendered from_____to_____

Was deposit required_____How much_____

Were bills promptly paid_____Was final bill paid_____

How much is still due from applicant_____

Remarks: _____

_____

_____

_____

_____

Date_____193__ By_____

_____

Form used by Idaho Power Company, front and rear views

the service loop or meter to advise new customers how and where to call for service connection.

All of the nine companies have quite similar methods for billing customers where they are unable to secure meter reading at the regular meter reading time.

One company uses a return postcard as a follow-up of "trouble complaints" and five have a form for use when the service or troubleman calls at the home and finds the customer away.

Two companies use a return postcard as a follow-up of major appliance installations; several others make personal calls, but only one of them requires a report to the office regarding the call.

Two companies formally acknowledge receipt of final payment on merchandise contracts.

Three companies have some standard greeting in answering telephone calls.

Two companies use a sample letter file with prepared paragraphs which can be used with good effect in answering particular complaints.

One company issues a courtesy card as recognition of a customer's good standing when leaving his present location. This is so designed that it is almost impossible for the customer to use same to secure credit other than from another office of the same company or pissibly another utility.

The committee is of the impression that the exchange of ideas by means of a folder showing the various forms used by member companies will prove of some benefit.

The corresponding national committee, under the able guidance of H. T. East, is carring out, we think, a very remarkable and useful program in assembling and passing on ideas and practices of the member companies all over the country and this committee would recommend to all member companies in this association, unless they are already doing so, that they subscribe for the pamphlet entitled, "Service Suggestions," published by the national committee, which can be secured from N.E.L.A. headquarters, at a price of $2 for the binder, including back numbers. The new numbers can be secured at a nominal price as they are issued. Partial information regarding the "Service Suggestions" is published from time to time in the N.E.L.A. Bulletin, but our information is to the effect that few companies in the Northwest are regular subscribers to these publications.

The committee hopes that its efforts for this year, while rather meager, will prove of some benefit to the member companies and that the copies of forms now in use that are attached to this report may give each of us an idea that will prove beneficial to our respective companies.

*Rural Electric Service and Farm Equipment**

Rural Electric Service

TO THE rural electric service committee was assigned the task of accumulating data for, editing and causing to be published, a handbook for rural electric service men. This handbook is to cover subjects in which the five states of this geographic division are most interested and to contain data applicable to the varied agriculture of the division.

The committee of last year had recommended this action, which was approved by the association executive committee, which in turn appropriated $600 to cover the estimated cost of publication. Our committee, organized in the fall of 1931, is composed substantially of the same personnel as the previous committee. It was the chairman's belief that such men would be more familiar with the subject and the background of the efforts leading toward such a publication. They could therefore more easily prepare the vast amount of data necessary to carry the publication of the handbook through to completion. In addition, most of the members of the committee are themselves rural service men and are therefore equipped to decide upon the type of information to be included.

The committee met in Portland Dec. 16, 1931, with seven members present. A thorough discussion was indulged in to determine the character of the handbook; that is, whether it should be (1) largely technical, concise and intended primarily for use by rural electric service men; or (2) general, with broad definitive terms which could be more handily used by salesmen; or (3) some variation or combination of the above two types, together with a bibliography of publications available on the subject. It was concluded unanimously that we should direct our efforts toward the publication of a handbook of the first type, which would, so far as possible, contain a maximum of accurate tables, curves, and useful data, with a minimum of explanatory and written matter. In a very small way it will

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* Report of the rural electric service and farm equipment committee, general bureau, Commercial Section. T. W. Delzell, The California Oregon Power Co., chairman.
Idaho Power Co.: R. S. Overstreet.
Montana Power Co.: J. C. Dow.
Northwestern Electric Co.: F. H. Robinson.
Oregon State College: F. E. Price.
Pacific Power & Light Co.: D. B. Leonard.
Portland General Electric Co.: W. M. Hamilton.
Puget Sound Power & Light Co.: J. C. Scott.
Utah Power & Light Co.: P. H. Craven.
The Washington Water Power Co.: Waldo Skuse.

resemble a typical handbook used by electrical and civil engineers.

Quite obviously, it will be more useful to those companies having a definite rural service department and to those men devoting a major portion of their time to the problems of farm electrification. It is our hope that, in addition, it will prove helpful to the farm implement dealers, and to county agents also. To be fully effective, it must be made useful to them.

It was decided at the December meeting that, because of the limited time, it was advisable for us to concentrate on only seven major sections of the book this year. The seven sections selected were: Irrigation, General, Poultry, Dairying, Fruit Production, Hay and Grain, and Soil Heating, each of these general sections to have several subheads.

It was the thought of the committee that a handbook, containing approximately 60 pages for the present, could include a large amount of concentrated data on these seven subjects, permitting us to complete the initial publication of the book within our budget.

Each member of the committee was made responsible for a certain section and the work of preparation is proceeding as rapidly as possible. Four sections have been completed in "dummy" form and it is expected that the remainder will be completed by the various editors by April 15. When this is done, the committee will again meet, assemble what photographs and cuts may be necessary, edit the several sections and in general put the handbook in final shape for printing.

The committee, in selecting the seven chapters above referred to, felt that by so doing the initial publication would contain data on phases of rural electrification in which each company in our geographical division would be interested. Due to the wide variation in climatic conditions and types of farming, it is recognized that possibly no two companies will be interested in exactly the same data and information. It is our thought that subsequent committees can prepare additional data on other subjects such as vegetables, lighting, domestic water supply, etc., and these can be added to the book from year to year. It is planned to prepare the book in loose-leaf form, therefore facilitating any additions or revisions to it.

From the information known relative to the cost of handbooks in other divisions, it is our belief that approximately 300 handbooks can be published for the $600 budgeted. These books will be sold to the member companies of the Northwest association, and thus the association funds will be reimbursed and in effect a revolving fund can be created with which to finance subsequent committees' work.

Our committee fully appreciates, as the association should, that the completion of this handbook requires much effort on our part to accumulate the data necessary, from original information and by extracting from other publications data and information which seems applicable to our territory. Because of the limited time and the limited number of sections, it is necessarily true that the initial handbook will no doubt fall far short of the ideal. We hope and believe that it will prove, however, to be of real assistance to utilities and to others engaged in promoting and developing rural electrification. To effect the results desired, the handbook should be placed in the hands of county agents, implement dealers and any and all others whom the farmers contact for advice on this subject. Also, since its data cannot be all-inclusive, copies of the national C.R.E.A. committee's "Electricity on the Farm," "Farm Electrification Research" and other publications of this type should be made available for these people and particularly for the rural service men, who can use them as general references.

Schools

During the present year two very successful rural electrification schools were held in this division, one at Corvallis, Jan. 25-27, and the other in Seattle, Tacoma, and Puyallup, Wash., sponsored by the Washington C.R.E.A. committee, Jan. 28-30, inclusive. At each of these schools representatives of the dealers and manufacturers were present and were given a prominent place on the program, and every effort was made to acquaint them with the possibilities of farm electrification. Over 70 hardware and implement dealers were present at the Washington meeting on the day set aside for their association. Members of the rural electric service committees aided these schools in every way possible, and took part prominently in their programs.

The farm equipment committee of this assocation, which this year happens to be composed of the same men, has disseminated to the utilities much information showing the potential possibilties of farm electrification, with respect not only to utilities, but to manufacturers and dealers. Since the personnel is identical, this is in a sense an activity also of the rural service committee.

Of the 34 utility members of the national association in this division, it is safe to say that ten of the larger companies do almost all of the power business. It is pleasing to note that of this ten, six are very actively engaged in promoting farm electrification and that the remaining four are moving to develop this load aggressively, making rural and market surveys and organizing departments to accomplish such a result.

Our committee would be negligent if we did not express at this time our appreciation of the assistance given us by other geographic divisions, by colleges within our division, by the state and national C.R.E.A. committees, and others, all of whom have most readily and generously given us the benefit of their data and permitted us to use, in part or whole, their publications or bulletins resulting from their studies.

Farm Equipment

THE purpose of the national farm equipment committee is "to survey the potential market for electrical equipment on the farm; to encourage research on new uses of electricity on the farm in conjunction with all interested and organized groups; to review present successful sales methods of farm electrical equipment, and to advise best means for merchandising this equipment."

Specifically, the national farm equipment committee has outlined two major activities for the year 1932, which are:

1. To make a determined effort to get every geographic division representative to see that every utility in his division that has a potential farm load is acquainted with the possibilities of farm electric load and urged to start some form of dealer stimulation to develop this business. It is the desire of this committee to get the plans now available for the development of the farm equipment load into use by every single company in the country that has a potential load.

2. To correlate pertinent information, for the stimulation of the utility group, manufacturers of farm electric equipment, and the dealers, in carrying out their farm electrical equipment development. The information of interest to the utility group is to include such information as the kilowatthour sales, the potential power requirements of our farms, the progress of the development of this potential kilowatthour load on existing lines, and the progress in reaching new farms. In addition to this, information will be supplied covering the potential farm market for electricity, together with such information as is available on the actual coopera-

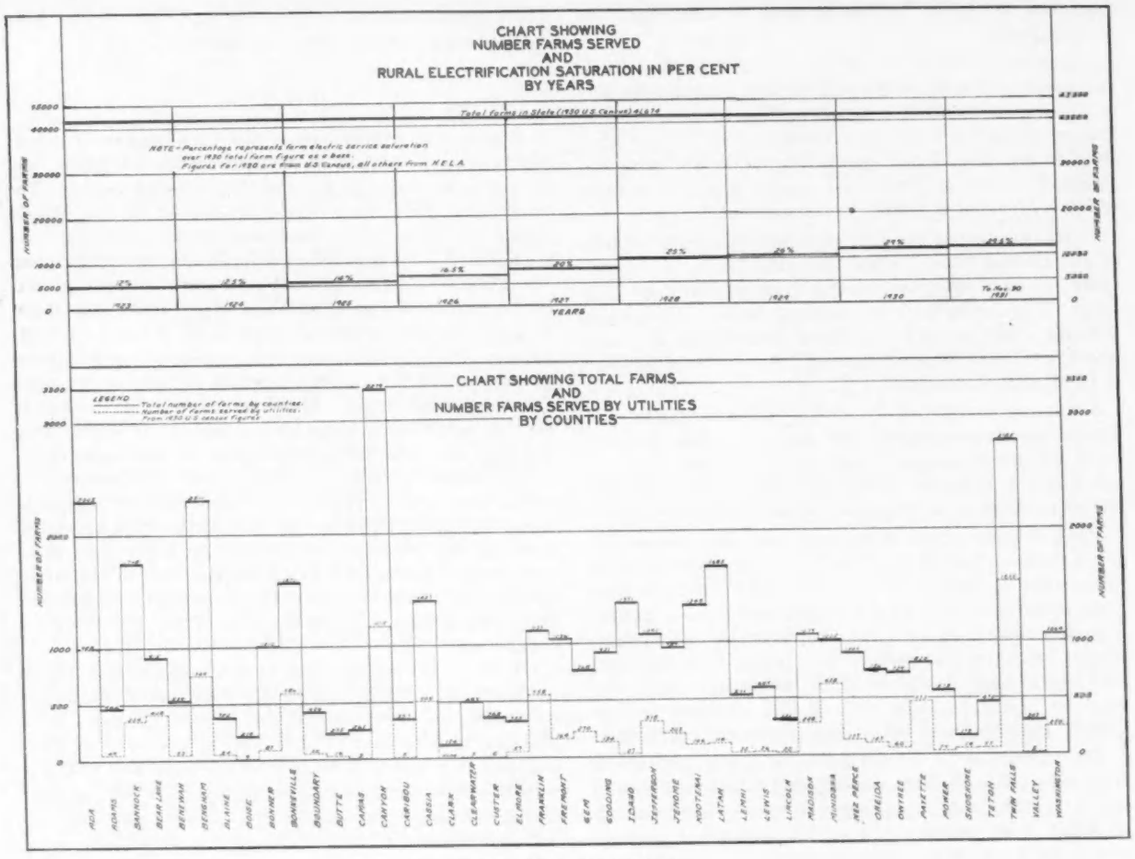

Fig. 1—State of Idaho

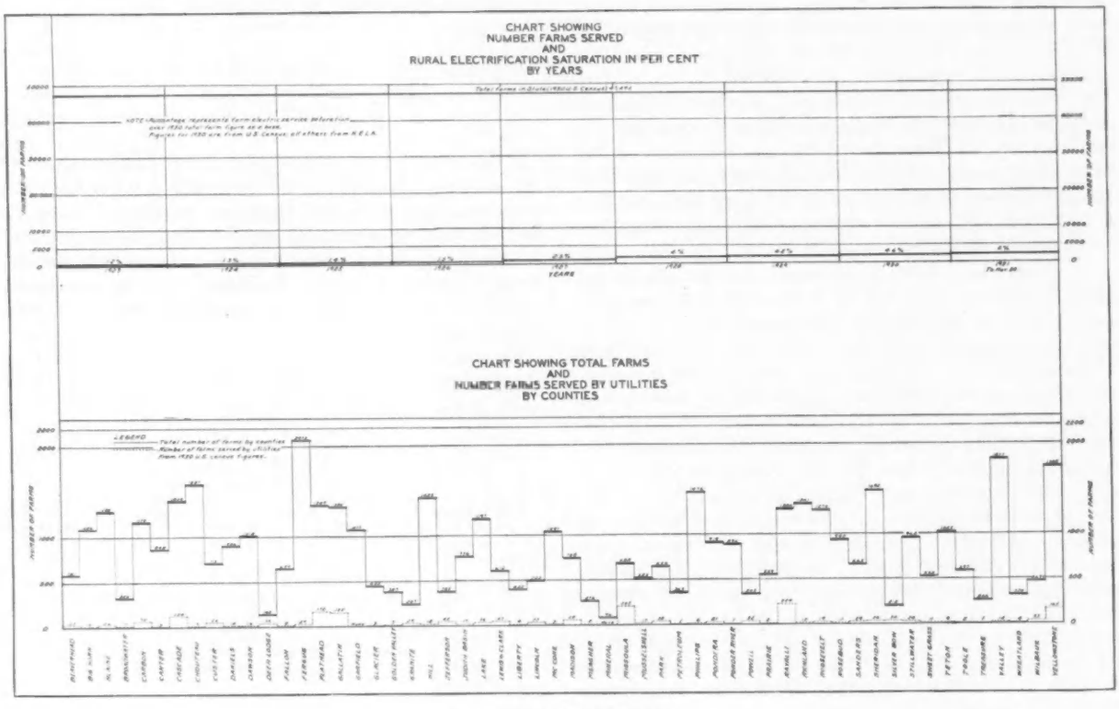

Fig. 2—State of Montana

tive dealer plans which are being used for the development of the farm electrical equipment business.

It is apparent from the above that the national farm equipment committee feels that there are enough plans now available to make it possible for any company to go out and do a real job of rural electrification. It may be that enough is not known about the varied uses of electricity, but certainly enough is known to permit a definite program.

We assume that similar purposes and objectives obtain for the farm equipment committee of the Northwest Electric Light & Power Association.

Here in the Northwest, the rural service and farm equipment committees have been combined. It was first our thought that, with the work involved in preparing the rural service handbook, we would not attempt to make up any report for the farm equipment committee, other than to answer the usual questionnaire for the N.E.L.A. However, it has developed that an interesting report could be made, along the lines of the major activities suggested by the national committee, and which possibly could be incorporated in part in our rural handbook.

For convenience, the report will be divided into the three parts: past, present and future.

Past

We know that, although the utilities even from the beginning have always had some farm customers, they have never gone after this business aggressively nor looked into the potential field much, until the organization of the state C.R.E.A.'s several years ago, which are now efficiently functioning. We know that many companies have organized a definite rural service department. We have also undertaken the distribution, to a selected list of farmers, of the magazine "Electricity on the Farm," various handbooks, the C.R.E.A. issues of "Electricity on the Farm" and other bulletins. Many farms have received the joint bulletins of the state C.R.E.A. and state colleges. Some companies have gone further and have made farm surveys of their respective territories. We have tried (too often unsuccessfully) to interest manufacturers and dealers to cooperate with us in the study of the rural field and its development. We learn that certain companies

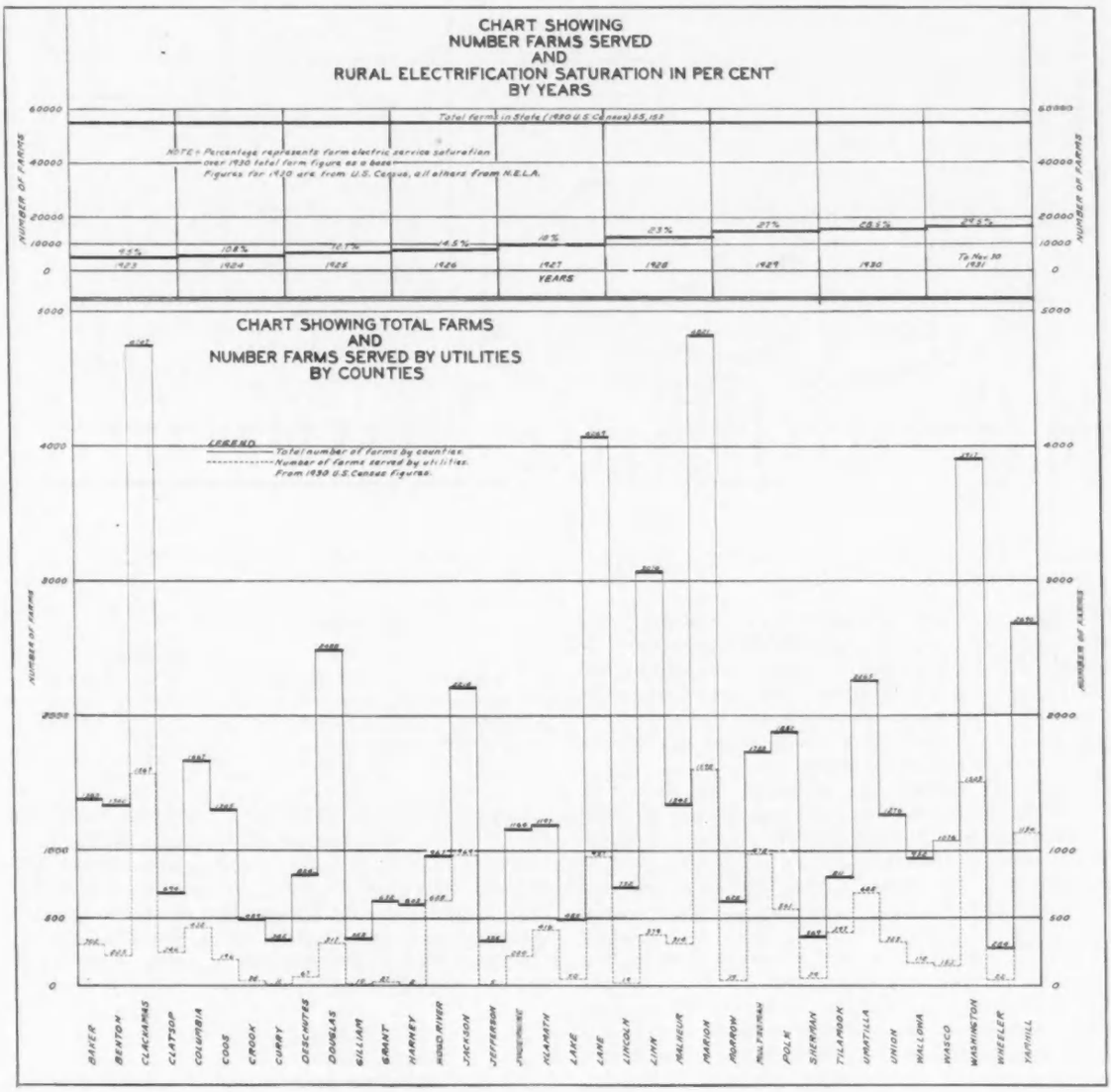

Fig. 3—State of Oregon

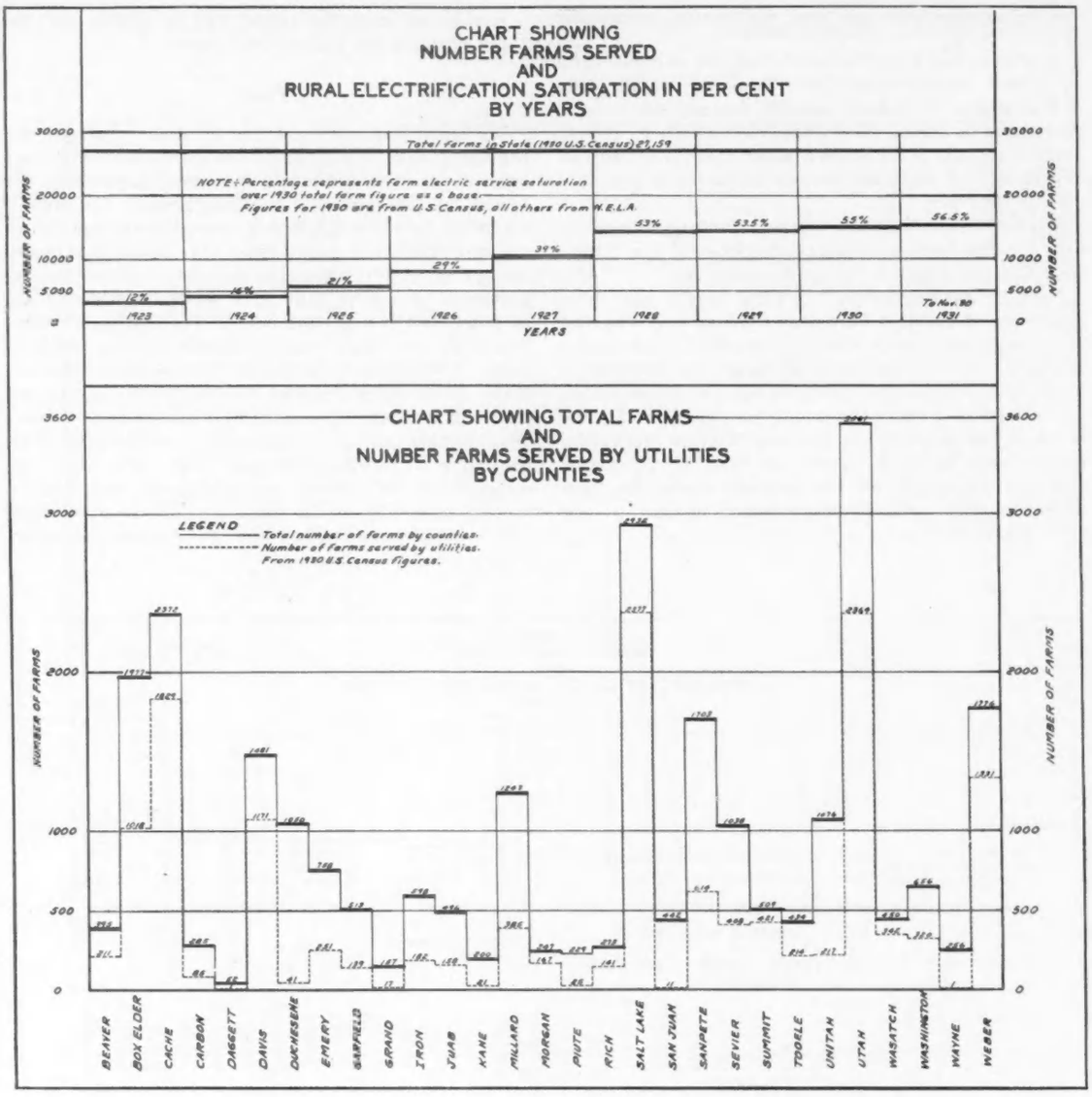

Fig. 4—State of Utah

that have more definitely entered the rural field have also conducted research investigations themselves, to determine what loads can be made adaptable and mutually profitable. Probably too much credit cannot be given the colleges of agriculture and the state committees, for the part they have played in bringing rural electrification to its present point.

By way of resumé, the results of this past work plus what, like Topsy, has just come to us, show that our farm customers have grown from a total of 27,580 farms served in 1923 to 82,832 as of Nov. 30, 1931, or an increase of 300 per cent over 1923 as a base, and assuming that the figure for total farms remained constant as of the 1930 census. One's first reaction is that the increase is a very remarkable record, but this is not so when we realize that the figure for the United States as a whole has increased 392 per cent in the same period and on the same basis.

We find that the saturation of farms served in the various states has increased as indicated in the following table:

Saturation of Farms Served

	1923 Per cent	1931 Per cent
Oregon	9.5	29.5
Washington	19	51
Idaho	12	29
Montana	1.2	5
Utah	12	56.5

Taking the figures for the five Northwest states, we find that the total number of farms as of the 1930 census is 242,385, and that the N.E.L.A. reports that 82,832 were served by public utilities as of Nov. 30, 1931. This is equal to a saturation of 34 per cent for the combined states from the latest available data, indicating, roughly, that one out of every three farms has central station service.

Present

We find ourselves as a nation in a worldwide depression. With less activity in the urban and indus-

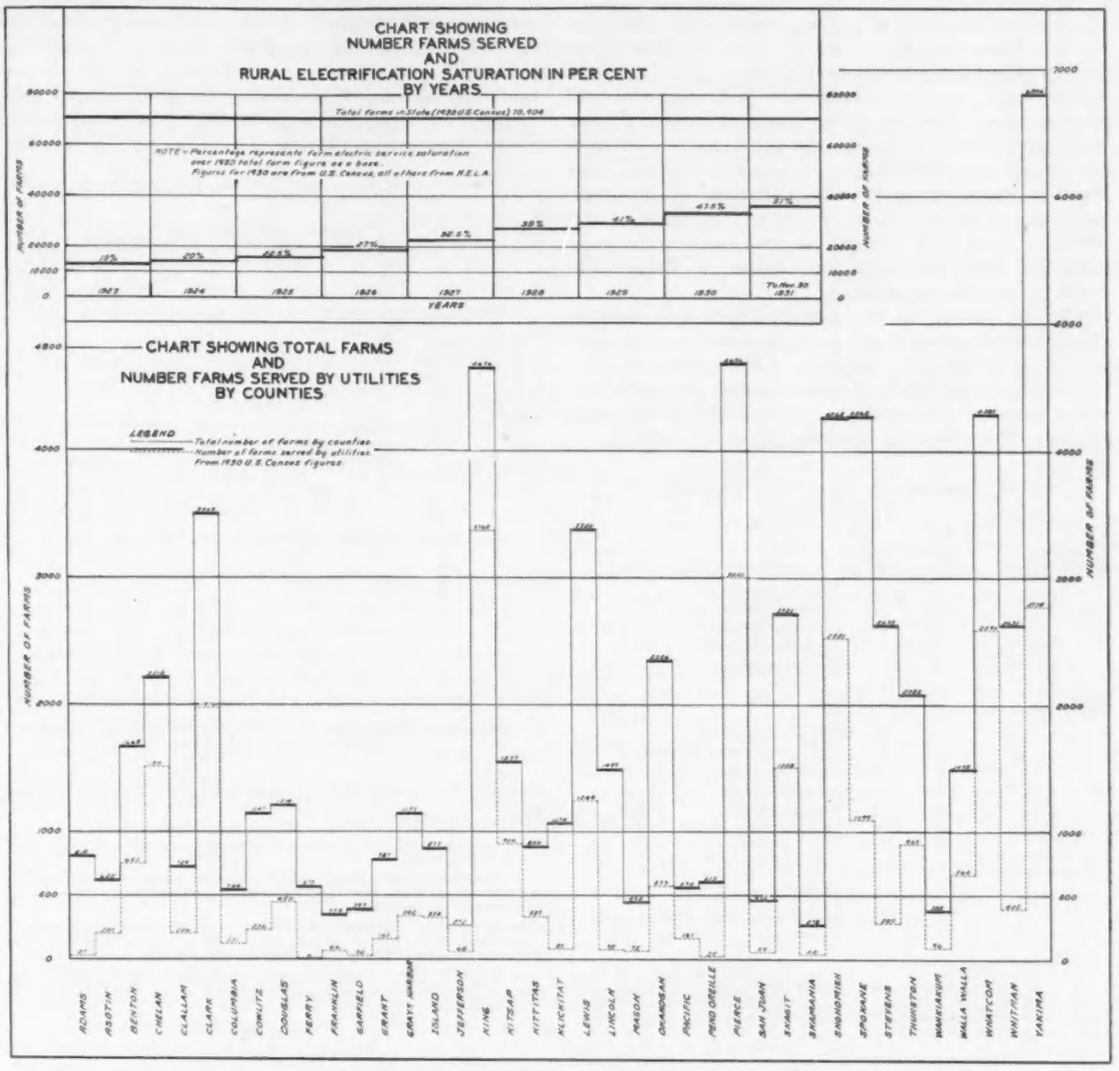

Fig. 5—State of Washington

trial field, we can in the recess at least utilize the opportunity presented to take stock of the rural field, with one eye on the past and the other on the future.

Every major company in our division is now adopting farm electrification as a project, or is keenly interested in its possibilities. A most encouraging thing about the rural farm load is that at this time, when our revenues and kilowatt-hour sales, with other business, are showing a decrease, no losses in farm load or revenue have been experienced in the Northwest division, which is true also of the United States. The figures available in this division prove that farm load, as a matter of fact, has increased.

We know that there is an opportunity and necessity for the development of irrigation load in the Willamette Valley; equal opportunities exist in other sections of the division. At least six of the large companies are making remarkable records in their territories in rural electrification, and the results of one in particular is outstanding.

The national C.R.E.A. under Dr. White has recently published a new issue of "Electricity on the Farm." Even a casual inspection of this book shows that there are literally hundreds of farm uses, all practical, and ranging from electrical devices to give the bull exercise, that he may better perform the duties he assumes, to soil heating, milk refrigeration, etc. Their research bulletin is constantly outlining and listing new uses.

I feel that it would be interesting to see how we have fared, in competition with others who are constantly offering their services to the farmers and competing with us for the farmer's marginal dollar. I find that while the electrical industry has a 34 per cent saturation in the five Northwestern states, the telephone people have reached 38 per cent, gas engines 27 per cent, household lighting systems 5½ per cent and automobiles 102 per cent. Incidently, only one out of every six farms has an electric motor.

One of the principal objects of the national committee was to acquaint manufacturers and dealers with the potential market. Mr. Wagganer has conducted a market survey of the entire United States, on behalf of the magazine "Electricity on the Farm." He received completed questionnaires from approximately 200,000 electrified farms, out of a total of 700,000 in the country. Applying the ratio worked out by him to our own district, I find that there is a potential market of over $11,500,000, taking only nine selected types

of merchandise and only those farms that are now connected and that have already made up their minds to buy. Obviously, in addition to these, there are vast numbers that are being connected each year and still another group that would be potential buyers if they were better acquainted with the practical uses of such equipment. As consideration is given to the fact that the nine items represent only a fraction of the practical uses of electricity on the farm, the scope of the potential market to the dealers and manufacturers is apparent, and, obviously, the figure of $11,500,000 could be greatly increased.

Also of interest to the manufacturers and dealers, should be the results of an equipment survey conducted under the same auspices. This nationwide survey indicates clearly the beneficial effect of continuous advertising, as compared to intermittent advertising, or none. The following is quoted from this survey:

BRAND PREFERENCE SHOWS EFFECT OF ADVERTISING

Range Manufacturer	*Now Own* Per ct.	*Plan to Buy* Per ct.	*Advertising Record*
1	35	69	Continuous pages
2	23	6	Not continuous pages
3	21	29	Continuous pages
4	11	½	No advertising
5	3	1	No advertising
Milker Manufacturers			
1	30	75	Continuous pages
2	14	11	Continuous small space
3	10	2	No advertising
4	10	1	No advertising
5	10	1	No advertising
6	6	6	Intermittent advertising
Brooder Manufacturer			
1	26	3	No advertising
2	12	22	Continuous adv. small space
3	7	70	Continuous adv. larger space

In explanation, let us look at the range manufacturer No. 1—35 per cent of the replies owned this particular make of range and 69 per cent of those who have decided to buy ranges selected this make. Manufacturer No. 1 was a full-page continuous advertiser.

Manufacturer No. 2 has general distribution, as shown by the fact that 23 per cent of the replies now own that particular make of range. Only 6 per cent of those who had made up their minds to buy ranges, selected this make. The interesting part is that this manufacturer was not a continuous page advertiser. In fact, the ranges were advertised only at infrequent intervals.

Note that advertiser No. 3 drew 29 per cent of those who had planned on buying ranges. This manufacturer was a continuous page advertiser, but for a shorter period than manufacturer No. 1.

Similar analysis can be made for milkers and brooders.

Summarizing these reports, we are forced to conclude that continuity in advertising is necessary. Let us look at it this way. There are some people who decide today to do certain things, others decide to make certain purchases—with every day come new decisions. Because of this fact, it is necessary to keep your products constantly before those who are possible users. These surveys prove conclusively that it pays to advertise to this great social group, i.e., to the farmers with electricity, if you would succeed in selling electrical equipment.

These surveys show that the more information regarding electrical equipment for use on the farm, that is sent out to this great group of people, the more influence it will have on their purchases. It means that they will invest a larger part of the money they have to spend in electrical equipment.

A third activity of the national committee which can be used to excellent advantage in the Northwest division will be the directory of farm equipment manufacturers, which should be off the press this year.

At the present time, we have outlined for us a number of plans for selling farm equipment, all of which vary somewhat, but are proving successful in their respective territories. These plans are contained in the report of the national farm equipment committee and can be readily secured. In the Northwest division, the method employed by the Idaho Power Company was presented, not because it is the only method, or the best, but because it is proving to be at least a good method. A study of this report, "Plans for Selling Farm Equipment Which Are Proving Successful,"

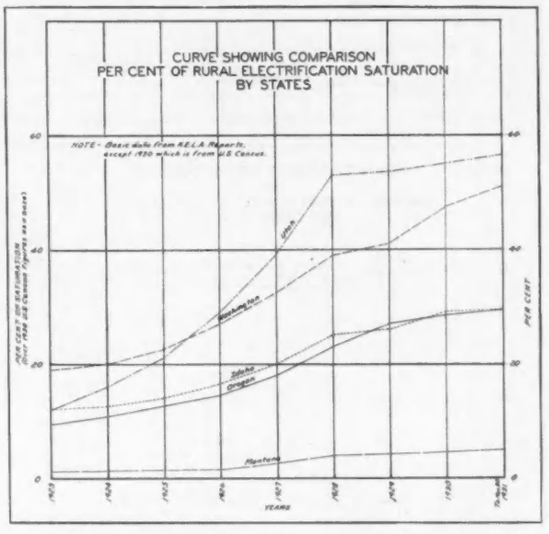

Fig. 6—Comparison by states in per cent of rural electrification saturation

which lists the methods of nine companies in the United States, indicates that:

1. It is necessary to have a satisfactory plan for making rural extensions,
2. A promotional form of rate, with increment steps low enough to permit the economical operation of farm electric equipment is necessary,
3. Six out of the nine do their merchandising through cooperation with the dealers, etc., which is particularly important in eliminating any dealer complaint,
4. Most of the companies have full-time rural representatives who are constantly in touch with the farmer and his problems.

Future

Coming now to the third general section of our report and realizing that the past two years have been open season on profits, it nevertheless can be said that, unlike the proverbial mule, we can look at the past with pleasure and view the future of rural electrification with optimism.

Looking at the future through the eyes of the utilities, we know that, of the 242,000 farms as of 1930 in the Northwest states, some 83,000 were served at the close of 1931. Let us assume that the revenue from one-half of the present customers can be increased to an average of $60 per customer per year, and of one-half to $120 per year. This would be on the basis of one-half lighting customers, with a considerable number of household and farm appliances, and the balance with the same equipment, plus ranges and water heaters. Let us also assume that 50 per cent of the farms not served can and will be connected in the next several years on the same relative basis. Using the average revenue-per-customer figures, as obtained from the United States census reports, the potential and available revenue from:

Oregon would then be	$4,150,000
Washington would then be	4,575,000
Idaho would then be	3,100,000
Montana would then be	4,140,000
Utah would then be	1,890,000
Total	$17,855,000

or in round figures, about $18,000,000.

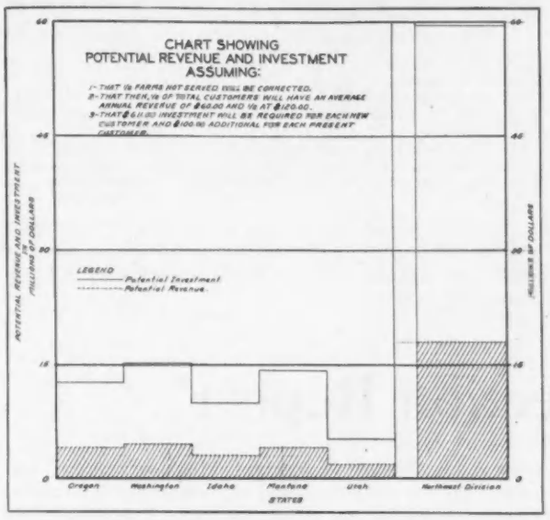

Fig. 7—Potential revenue and investment

The first question is, of course, how much additional investment would be required to obtain this additional revenue. The January issue of *Electrical West* states that for the eleven western states the average investment per customer is $611. In 1930 there were 171,148 farms in the Northwest Division not served by utilities. Assuming that the average new investment per customer will be the same, then the additional investment necessary on this basis would therefore be $52,285,000. Let us also assume, for liberal measure, that an additional investment of $100 per present customer will be required, or $7,000,000, making a grand total of $60,000,000 new capital. The next natural question is "Is such an investment justified?" The answer, it seems to me, is that the ratio of investment to revenue would be 3.3 to 1, which compares very favorably with many of the present extension policies of 2.5 and 3 to 1. Also it can be kept in mind that the figure of $611 per customer included all types of plant; that is, distribution, transmission and power house capital accounts, making the $7,000,000 which we added somewhat superfluous. We shall include this, however, as an offset to the expectation that additional rural customers will no doubt cost more per customer in the future, due to the fact that those most easiily served have naturally been connected first.

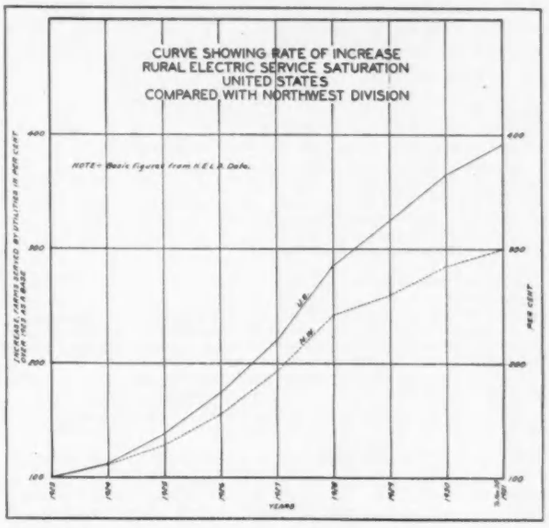

Fig. 8—Curve showing rate of increase in rural electric service saturation of the United States compared with the Pacific Northwest

The conservativeness of the revenue figures for new customers can be proved by adding that it simply means an average annual consumption of 4,000 kw.-hr for each combination service (range, lights, etc.) at a rate of 3c per kw.-hr., or a consumption for lighting and appliance customers of 1,500 kw.-hr. per year at a rate of 4c. Looking at this another way, the total estimated potential revenue from farms, not at present served, is $15,000,000. This amount would pay 17 per cent fixed charges on the investment of $52,000,000 required for them, and leave a balance of over $6,000,000 to reimburse the utilities for kilowatt-hour costs, losses and other charges, including profit. The $2,500,000 additional revenue from existing customers readily justifies the estimated $7,000,000 additional investment, if necessary, and no comment is needed, since admittedly we will always strive for more kilowatt-hour sales from existing customers.

This may seem high, but it surely can be done, and easily. For instance, if I interpreted them correctly, the figures of the Idaho Power Company indicate that its average kilowatt-hour sale per farm customer was 3,700 in 1930, and I am sure that it will not admit it is through in the field of rural development. As a further comparison, the report of the 1930 rural electric service committee shows that the Washington Water Power Company farm customers used an average of over 7,000 kw.-hr. per customer and that the average on the Copco system is very nearly 6,000, including sales to farm pumping plants. *Electrical West* for February, 1932 states that it is not unreasonable to expect an average minimum consumption of 10,000 kw.-hr. per farm customer.

Our estimate of $60 and $120 per customer, respectively, compare favorably with a present average revenue per customer (all classes) of $87.20 for the United States and $83.60 for the eleven western states. I realize that these average figures take into account industrial and commercial customers, but even if this be true, it is likewise true that we can expect here in the Northwest to add new farm irrigation plants, for instance, which will certainly help the average.

Should the *Electrical West* prediction of 10,000 kw.-hr. per farm customer be achieved, then obviously the estimate of $18,000,000 potential revenue could be doubled, which certainly would be a result to be desired.

In our study of this subject, a resumé of the foregoing facts and forecasts has led us to the inescapable conclusion that the rural electrification field is one, if not the largest, potential market for kilowatt-hours we have, and for development awaits only our more aggressive action. The beauty of it is, that the business is here within our gates, and needs no concentrated and expensive campaigns by chambers of commerce to bring it to our states. It is here. Further, its development can be mutually profitable to all concerned—farms, utilities, dealers and manufacturers.

Another conclusion is that the benefits derived from better relations with the agricultural groups will be real, though intangible, and that there will be less agitation for power development by the states at "no taxpayers' cost," and, if properly handled, no dealer criticism. Last, but not least, better farmers will remain on and be attracted to the farms, thus creating and advancing agriculture as a whole, a big factor in the stabilization of our own systems.

Before closing, there are a few observations and recommendations that should be given full considera-

tion in any rural service program. These suggestions are presented with full knowledge that each company should and will devise its own particular set-up to give results.

1. Continuous reliable electric service.

2. Continuous advertising (of a positive nature) and publicity, realizing that the best is "user publicity," that is, word-of-mouth advertising by one farmer to another.

3. Field demonstrations of equipment.

4. Employment of full-time trained rural men, who can intelligently contact farmers. The more intelligent our contacts, the more successful our program.

5. Liberal rural extension policies and combination rates, with demand rather than connected-load clauses.

6. Farmer instruction so that he may secure maximum efficiency from his equipment, with minimum cost, thus becoming a satisfied customer and booster.

7. Training existing utility organizations rather than discarding them. Close cooperation of all employees, so that accurate information can be disseminated and the full objective attained.

8. Since in many cases other competitive types of equipment will be displaced, the problem of servicing must receive attention.

9. Desirability of good records for our farm business.

10. Cooperation with dealers, merchants, county agents, etc., that they may be allies not critics or competitors.

Attached to and made a part of this report are eight charts showing comparative curves and data, much of which is original and can be advantageously used by those interested.

Engineering Section Report*

THE Engineering Section investigated mainly problems of operation which would enable the member companies to produce economies in expense. Some new developments which are in the experimental stage were also presented for consideration.

Problems of operation to produce economies were as follows: Losses in distribution systems were discussed by the overhead systems committee. While losses are always with us and it may not be economical to make the necessary expenditure to reduce them, it appears that there is an opportunity to make a saving in these losses. The meter committee presented a very thorough digest of the meter work of the various member companies, which will allow each company to compare methods and to take a leaf out of the other fellow's book. The same opportunity of comparison of activities is afforded in safety work, as a result of the report of the accident prevention committee. Activities of member companies were included in one report and accident experience in another. The latter report also contains a classification of accidents, which furnishes guide posts for accident prevention activities. The foreign systems coordination committee presented an example of whole-hearted cooperation between power and communication interests in the solution of a problem involving inductive interference. A number of the kinks of radio interference from electrical appliances were presented. A report by the underground systems committee on operation and maintenance of underground a.c. networks furnished considerable data which should help member companies to accomplish operating and maintenance economies on their systems. The questions of ventilating and cooling, grounding, and obsolescence of equipment were discussed by the electrical apparatus committee. The prime movers committee discussed methods of feedwater treatment and cinder and smoke elimination. The latter subject has received considerable attention in the East, where ordinances to eliminate smoke nuisance have been discussed. The question of frequency and load control was presented by the hydraulic power committee. This apparatus apparently will not only so control frequency that no trouble will be experienced with electric clocks, but will give economies of power production by better distribution of the load between units in the same plant and between plants on a system and between systems. Discussion of protective coatings for hydraulic structures and methods of hydraulic turbine testings furnished guides for economical expenditures. The power systems engineering committee presented plans for serving rural communities. The report considers the broader underlying principles of the over-all planning of transmission, substation and distribution facilities of power systems concerned in supplying rural territory, whereby economical and satisfactory service can be rendered.

Subjects looking to the future in the industry were covered as follows: underground service to residential areas; more economical design of substations in the future; new apparatus and new methods of serving rural communities; reading customers' meters at the central office by remote indication; the use of wrought iron plates in future penstock construction; new remedies for radio interference on pintype insulators and conductors; lightning protection for distribution transformers; the possible competition of the Diesel-electric generating stations to the industry.

General Meeting

The ninth annual general meeting of the section was held in Portland, Ore., April 13-15, 1932, with headquarters at the New Heathman Hotel. N.E.L.A. headquarters was ably represented at this meeting by J. O'R. Coleman representing Major H. S. Bennion. Mr. Coleman brought a message from headquarters that was of interest to all and presented frank and constructive criticism throughout the discussions. Complete proceedings of the meeting are to be published in pamphlet form.

Details of the program were as follows:

Meter Committee, A. H. Kreul, chairman—

1. Meter committee reports, by A. H. Kreul, Portland General Electric Co.

2. Standard Practices and Requirements for Electric Meters, by L. D. Snow, Puget Sound Power & Light Co.

3. Remote Reading of Watthour Meters, by W. A. Leidigh, Portland General Electric Co.

Foreign Systems Coordination Committee, H. H. Schofield, chairman—

1. A Problem in Inductive Coordination, by C. B. Carpenter, engineer, Pacific Telephone and Telegraph Co., and E. W. Conroy, superintendent of light and power, Puget Sound Power & Light Co.

2. Radio Interference from Electrical Appliances, by Ellis Van Atta, radio engineer, Pacific Power & Light Co.

3. The Coordination of High-Voltage Transmission Lines with Radio, Prof. F. O. McMillan, Oregon State College.

Electrical Apparatus Committee, J. Hellenthal, chairman—

1. Substation Design, Economical Design of Substations of 1,500 Kva. and Less, by F. M. Lewis, Northwestern Electric Co., and A. Shipek, Puget Sound Power & Light Co.

2. Equipment for Serving Rural Lines, by G. M. McClellan, Mountain States Power Co.

3. Study of Methods of Ventilating and Cooling Electrical Apparatus, by D. R. McClung, Pacific Power & Light Co.

* Executive Committee: E. H. Collins, chairman; W. S. Hill, vice-chairman. J. C. Boyle, G. E. Quinan, P. P. Ashworth, O. B. Coldwell, E. F. Pearson, O. L. LeFever, V. H. Greisser, H. H. Cochrane, H. L. Senger, O. D. Lanning, J. B. Fisken, J. E. Yates, H. H. Schoolfield, A. H. Kreul, J. Hellenthal, A. H. Greisser, C. H. Hoge, A. T. Purton, S. B. Clark, M. T. Crawford.

4. Obsolescence of Equipment, by J. C. Henkle, Portland General Electric Co.
5. Grounding, by B. C. Russell, Idaho Power Co.
6. Trends of Apparatus Development, by A. W. Copley, Westinghouse Electric & Mfg. Co.

Prime Movers Committee, A. H. Greisser, chairman—

1. Present Methods of Feedwater Treatment in Use in the Northwest, by A. L. Pollard, Puget Sound Power & Light Co.
2. Cinder and Smoke Elimination, by J. A. Hooper, Northwestern Electric Co.
3. Diesel-Electric Generating Stations, by A. H. Greisser, Portland General Electric Co.

Accident Prevention Committee, J. B. Fisken, chairman—

1. Accident Experience of Member Companies and Classification of Injured Employees, by Wallace Brier, Puget Sound Power & Light Co.
2. Safety Activities of Member Companies, by J. D. Ellis, Northwestern Electric Co.
3. Hazards Due to Vines on Poles, by C. F. Young, Portland General Electric Co.

Code Committee, S. B. Clark, chairman—

1. Review 1931 Code Revisions as Affecting Public Utilities, by S. B. Clark, Northwestern Electric Co.
2. Wiring Adequacy in the Code, by R. E. Thatcher, Puget Sound Power & Light Co., and Hal Gardner.

Overhead Systems Committee, T. A. Purton, chairman—

1. Lightning Protection for Distribution Transformers, by Prof. E. C. Starr, Oregon State College.
2. Vibrations of Transmission Line Conductors, by C. O. Crane, Idaho Power Co.
3. Losses in Distribution Systems, by P. P. Ashworth, Utah Power & Light Co.

Power Systems Engineering Committee, M. T. Crawford, chairman—

1. The Value of Power Systems Engineering Committee Work to Company Executives, by M. T. Crawford Puget Sound Power & Light Co.
2. System Planning for Economical Transmission, Substation and Distribution Development for Rural Service. (The results of a study of the practices of member companies in the Northwest, made by the members of the power systems engineering committee.)

Underground Systems Committee, C. H. Hoge, chairman—

1. Small Town Street Lighting, by Craig P. Elliott, West Coast Power Co.
2. Operation and Maintenance, A.C. Underground Network, by Wallace Quistorff, Puget Sound Power & Light Co.
3. Underground Distribution for Residential Districts, by T. W. Swartz, Northwestern Electric Co.

Hydraulic Power Committee, J. E. Yates, chairman—

1. Frequency and Load Control
   (a) New Developments, by S. Logan Kerr, I. P. Morris Co.
   (b) Operating Experience, by J. S. McNair, The Washington Water Power Co.
2. Hydraulic Turbine Testing, by W. A. Hill, The Washington Water Power Co.
3. Rainfall Cycles, by Harry Olsen, California Oregon Power Co.
4. Protective Coatings for Hydraulic Structures, by J. H. Siegfried, Pacific Power & Light Co.
5. Wrought Iron Plates as Substitutes for Steel Plates in Penstock Construction, by A. N. Geyer, Woodward Governor Co.

Miscellaneous Activities

General work of the section was as follows: E. F. Pearson was appointed to represent the section on a subcommittee to formulate specifications for Western fir poles. The power systems engineering committee was formed during the association year. It should be stated that this committee's function is approached from the system point of view and is not to deal with interconnection. Its work is to produce guides for developing existing systems along the most economical lines. Three delegates were sent to each of the national group meetings and one to the Pacific Coast Electrical Assn. group meetings. These delegates made written reports which were distributed to the member companies in order that they might make use of the information at the earliest possible moment. The radio interference experiments were continued at Oregon State College with funds from the national association. A list of executive committee meetings and list of delegates to other group meetings follow:

Executive Committee Meetings—Sept. 10 and 11, 1931, Portland, Ore.; Jan. 14 and 15, 1932, Seattle, Wash.; April 13 to 15, 1932, Portland, Ore.

Delegates to National Group Meeting—Oct. 5-9, 1931, Cincinnati, Ohio—E. H. Collins, J. Hellenthal, T. A. Purton.

Delegates to National Group Meeting—Feb. 1-5, 1932, New York City—W. S. Hill, C. H. Hoge, S. B. Clark.

Delegate to P.C.E.A. Group Meeting—March 9-11, 1932, Fresno, Calif.—H. H. Schoolfield.

It will be noted that the meeting of the executive committee, usually held in November, was omitted. The average attendance at executive committee meetings was fourteen.

The executive committee, in planning economies for next year's activities, made recommendations for one year only, as follows:

Consolidate overhead systems and foreign systems coordination committees.

Consolidate electrical apparatus and meter committees.

Reduce the personnel of the executive committee, so that committee chairmen would be member company representatives and thus reduce the number of members at large.

Reduce the appropriation to send delegates to national group meetings.

The executive committee recommended the appointment of officers for next year, as follows: chairman, E. H. Collins; vice-chairman, W. S. Hill.

The chairman wishes to take this opportunity to express his appreciation of assistance and cooperation rendered by the president, secretary and other officers of the association. Also the help and good fellowship of the vice-chairman, committee chairmen and members of the Engineering Section in planning, developing and presenting the work of the section.

Public Relations Section Reports

*Report of Executive Committee**

AT THE beginning of the current association year, the Public Relations Section submitted a report to the president of the association indicating the possible advisability of reorganizing the assignments within the section. The attached letter indicates the nature of this recommendation and is made a part of this report. Under its terms considerations have been carried forward under three committees.

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* Report of the executive committee, Public Relations Section, A. S. Bennion, Utah Power & Light Co., chairman.
Idaho Power Co.: R. B. King.
Montana Power Co.: J. C. Ryan.
Northwestern Electric Co.: L. T. Merwin.
Portland General Electric Co.: W. P. Strandborg.
Puget Sound Power & Light Co.: L. R. Coffin.
Utah Power & Light Co.: Charlotte Cummings, George M. Gadsby.

Employee Welfare and Training Committee

The outstanding piece of work done under the employee welfare and training assignment for the year has been the employee information program. To date the following pamphlets from national headquarters have been given careful study in groups of ten throughout the companies of our association:

Our Job.
Electric Service to the Factory and the Factory Worker.
Government Ownership.
The "Power Trust" Myth.
Free Speech Except for Utilities.
Interconnection.
The Cost of Electric Service.
Public Regulation of Electric Utilities.

These pamphlets have been supplemented by local booklets and other materials offering additional solutions to some of the problems now confronting the industry.

Incomplete reports received thus far indicate that 5,927 employees have participated in this program. The response generally has been as enthusiastic as it has been intelligent.

ADVERTISING AND PUBLICITY COMMITTEE

The preliminary report of this committee published herewith gives the point of view of this committee to date.

WOMEN'S COMMITTEE

The work of this committee is reflected in the minutes of the meeting held in Portland, Feb. 19, 1932, published herewith.

Supplement to Report of Executive Committee

Sept. 5, 1931.

Mr. P. M. Parry, President,
Northwest Electric Light and Power Assn.,
City.

MY DEAR MR. PARRY:

The Public Relations Section of the Northwest Electric Light and Power Assn. is now carrying forward its program through the following eight committees:

1. Advertising and publicity.
2. Customer ownership.
3. Cooperation with educational institutions.
4. Employees' relations with the industry.
5. Employees' relations with the public.
6. Relations with financial institutions.
7. Public speaking.
8. Women's committee.

If each of these committees launches a vigorous program and holds the meetings necessary to carrying it out, we face an expenditure of money not altogether in keeping with the curtailments of a depression year. Moreover, as I analyze the work attempted to date by these various committees, there seems to be a good bit of overlapping. Then, too, many of the problems encountered seem to be problems for executive rather than for committee consideration.

I doubt that eight subcommittees can hope to have the enthusiastic administrative backing essential to successful, purposeful work.

Under all these circumstances I submit for your consideration and for the judgment of the executive committee the advisability of reducing the number of committees from eight to three, namely:

Advertising and publicity.
Employee welfare and training.
Women's committee.

The assignment to the advertising and publicity committee might well include such subjects as:

1. A clearing house for advertisements.
2. Results obtained in various company advertising campaigns.
3. Personal contacts with newspaper publishers.
4. Advertising mediums.
5. Market surveys.
6. Types of advertising copy.
7. Possibilities and means of good will advertising, both urban and rural.
8. Oral selling as a means of bettering relations with the customer.
9. Cooperation with independent dealers in advertising merchandise.

The employee welfare and training committee would be charged with the responsibility of providing for:

Welfare—

Employee "mutual aid" organizations
Health
Insurance
Thrift
Working conditions
Safety and first aid.
Retirement
Placement, transfers and promotions.

Education—

This year's employee information program
Other educational courses
Customer contact training
Group conferences
Division meetings
Public speaking, essay or other contests.

Recreation—

Athletic
Social.

The women's committee will promote among women employees a better understanding of:

Utility organization and operation
Home uses of electricity
Improved service to customers
Women's place in the public utility field.

Yours sincerely,

(Signed) ADAM S. BENNION,
Chairman, Public Relations Section.

*Advertising and Publicity**

ON COMPLETION of the organization of the committee, the chairman wrote to Joseph B. Groce, chairman of the national advertising and publicity committee, asking for an outline of the set-up, policy and activities of the national program for the current year. It was felt that regional committees out in the field should be guided primarily by the policies, counsel and instructions of the national organization.

In reply to this inquiry, Mr. Groce wrote in part as follows:

The budget of the N.E.L.A. is to be, I understand, considerably reduced, and many of the activities discontinued, or at least limited. Our committee is just at present in *statu quo.*

When something definite develops, and I think it may a little later, I will certainly write you in detail, for I think you can be of great help to us up in the Northwest corner of the United States.

Since this letter, nothing has been heard as to activities of the national committee.

Our Northwest committee realized the handicap under which it would have to work this year. In former years the chairman has been able to visit all the large companies and get into personal contact with his committee members, and thus was able to work out a program, but recently such trips have not been possible.

Moreover, curtailment or discontinuance of advertising activities has been the prevailing rule this year. According to our information, only a few companies have been doing any advertising "campaigning" for many months. The Puget Sound Power & Light Co. has run an institutional campaign of some magnitude, and some other companies have run or are planning some measure of good will or promotional advertising, but by and large it has been a lean year for this type of endeavor.

The committee is still hopeful that something may develop, either by way of a national assignment or in the nature of a local job, that will permit it to become active. In the meantime, we ask that this be considered a progress report.

* Report of the advertising and publicity committee, Public Relations Section, W. P. Strandborg, Portland General Electric Co., chairman.
The California Oregon Power Co.: H. L. Bromley.
Idaho Power Co.: E. C. Kiersted.
Puget Sound Power & Light Co.: C. T. Bakeman.
Utah Power & Light Co.: M. L. Cummings, Jr.
The Washington Water Power Co.: E. J. Crosby.

*Women's Committee**

THE first meeting of the women's committee was held Feb. 19, 1932, at the Heathman Hotel, Portland, Ore., with the following members present:

* Report of the women's commitee, Public Relations Section, Charlotte Cummings, Utah Power & Light Co., chairman.
The California Oregon Power Co.: Viola Templeton.
Eastern Oregon Light & Power Co.: Rose Perkins.
Grays Harbor Railway & Light Co.: Esther Miller.
Idaho Power Co.: Mary Newhouse, Mrs. Gertrude McDevitt.
Mountain States Power Co.: Margaret Hurst.
Pacific Northwest Public Service Co.: Marguerite Butler.
Pacific Power & Light Co.: Gertrude Humphrey.
Puget Sound Power & Light Co.: Mrs. Nell Laws.
Utah Power & Light Co.: Mrs. Margaret Schofield, Mrs. Ardell Welch.
The Washington Water Power Co.: Mrs. Lucile Ramirez.

Charlotte Cummings, chairman; Viola Templeton, Margaret Hurst, Marguerite Butler, Gertrude Humphrey, Mrs. Neil Laws, Mrs. Lucile Ramirez, Mrs. Gertrude McDevitt, Mrs. Ardell Welch.

The following members were absent:

Esther Miller, Rose Perkins, Mary Newhouse, Mrs. Margaret Schofield.

Guest speakers were:

P. M. Parry, vice-president and commercial manager, Utah Power & Light Co., Salt Lake City, Utah.

George C. Tenney, editor, *Electrical West*, San Francisco, Calif.

A. C. McMicken, general sales manager, Portland General Electric Co., Portland, Ore.

Chairman Cummings opened the meeting by stating that one of the purposes of the women's committee was to formulate plans for the education of the women of the industry, so that they might be able to answer intelligently questions that may be asked concerning the electric light and power industry.

Guest Speakers

Mr. Parry, president of the Northwest association, was introduced by Miss Cummings. He discussed the education of employees. He especially stressed the retarding effects of government ownership, stating that 90 per cent of the people agitating it do not know what it really means. He urged that the women's committee carry on the educational work which would go a long way to suppress this agitation.

Mr. McMicken spoke on merchandising by public utilities, citing instances where trade associations had secured legislation to prevent public utilities from selling merchandise and the adverse effects obtained. He referred to the committee report of merchandising activities in the May 15, 1931, issue of *Electrical West*, which sets forth the power companies' reasons for being in the merchandising business, their accomplishments, and their belief that by merchandising they are making it better for the dealers than if they were not in the business. He was especially emphatic in his statement that it was essential for public utilities to pioneer in the merchandising field, as the prohibitive cost made it impossible for dealers to do so. Ultimately, the power companies get increased revenue, the customers get lower rates, there is a demand created for electrical appliances, and the dealers benefit through this demand. He said that there is plenty of field for both the dealers and the public utilities, as there is no saturation point. Mr. McMicken suggested that one of the women's committee meetings be held for the purpose of informing the employees as to the reasons for public utilities being in the merchandising business.

Mr. Tenney stressed the thought that it is up to the individuals of the power companies to take an active interest in the load building and merchandising, which may carry a company over a depression period, when industrial consumption decreases. People will spend money to cut expenses in their homes, and to better conditions, and it is a favor to a housewife to sell her an electrical appliance. He urged the women's committee to familiarize itself with the sales programs and to talk to associates and friends. In many companies bonuses are offered for sending in names of prospective purchasers of electrical equipment, which result in a sale. Many employees do not appreciate this opportunity to increase their earnings, and do not understand that the continuity of employment depends on how much load is carried.

In speaking of home service, Mr. Tenney advised the home service workers and home economists not to be too efficient, not to be superior. For instance, in calling on a housewife, who has called for assistance in the operation of an electric range, the home service worker should be neatly, but not gaudily dressed, and in demonstrating the cooking of foods, care should be taken to cook those things which the average family would prepare. He suggested that public utilities organize an advisory service to assist the homemaker in matters pertaining to budgets, simplifying home duties, etc. Mr. Tenney stated, "Women are essential to the conduct of the electric light and power industry."

Committee Activities

A discussion followed regarding the various company activities in the women's department, and suggestions were made for women's committee programs, such as having a program on mending appliances, use of appliances by employees, etc.

Miss Butler reported on the very successful home lighting course given to the girls of her company, as follows:

> This was the first class for our women employees and consisted of twelve Monday evening lessons, with Walter E. Potter of the Incandescent Lamp Department of General Electric Co., and T. W. Fitch, illuminating engineer of our company, as instructors. Very interesting lessons with moving pictures, slides, material, lamps, etc., were given, and an art teacher came in two evenings and taught lamp-shade making. Printed lessons were given out at each meeting and written answers to questions contained therein were required, these being graded by experts. In addition the class was required to light a home on a blueprint floor plan supplied them, accompanying it with a 200-word article. This class was made up entirely of girls who volunteered to take the course. The class "graduated" at the January women's meeting, which had an inspiring effect on the audience and gave the girls of the class considerable glory. At that time, Mr. Fitch explained something concerning the national lighting organization, the "Sorority of Light," and gave each girl who had successfully completed the entire course, the scarab pin signifying membership. Mr. McMicken, our general sales manager, then presented engraved certificates from Nela Park, Cleveland, indicating membership in the Home Lighting League. These certificates were signed by Mr. Potter, by E. W. Commery of Nela Park, and by our president, Franklin T. Griffith. Mr. Coldwell, vice-president, then presented the prizes, which went to the three girls having the highest average over the course. The prizes consisted of three beautiful ornamental lamps given by the General Electric Co. and our company.
>
> We are still holding a home lighting class for saleswomen and demonstrators, which meets monthly after the women's committee meeting; this month (February) will see the conclusion of this class. One ornamental lamp will serve as prize.

Considerable interest was manifested by a number of the chairmen, and questions were asked regarding the practical details of putting on the course.

At the beginning of the afternoon session, the question of employee information programs was discussed. All but two of the companies are conducting these programs. In some instances the men and women of the company meet together, and in some they hold separate groups. In all cases where the program is being followed, it is in addition to the regular women's committee meetings.

Reports of the chairmen on the work covered this year to date were given as follows:

Pacific Northwest Public Service Company—

In this group there is a new chairman for each month's meeting. She helps plan the program and makes the introductions at the time of the meeting. She is selected alphabetically from the executive committee, consisting of six members who are appointed every six months. Some very interesting meetings have been held. Among the subjects covered have been: public relations, and "this and that" concerning the railway situation, touching on fares, franchise and service phases. There was also presented the playlet entitled "Are We In It?" "Why Can't We Heat Our Homes Electrically?" was the subject of another meeting, with a discussion on the problems of the light and power department. One of the features of the December meeting was an attractive display of the smaller

appliances which are particularly suitable for Christmas gifts, and a talk was given concerning their use, quality and price. A playlet entitled "Scrooge Buys His Wife a Christmas Present" was presented by three women employees, who took the parts of Mr. Scrooge and two electric store clerks. In January a talk was given by one of the men of the legal department on the subject of "The Need for a System of Mass Transportation in a City the Size of Portland." Mrs. Chrystine B. Carter of New York City and Dallas, Texas, an interior decorator and lecturer, was the speaker at the February meeting, this being the first meeting where an outside speaker had been asked to come in, and where the subject was not an electrical one. Mrs. Carter talked on "Personality in the Home," and dealt with interior decorating.

Bowling is a new activity among the girls of this group this year, 30 girls taking part.

There are also 25 girls taking classes in gym., swimming and tap dancing at the Y.W.C.A.

There are 35 girls taking the public speaking class under the direction of Mrs. Mabel Maxwell. These are dinner meetings.

At Christmas time, the girls raised the money and took care of needy families which have, or did have, some connection with the company. This year staple supplies were sent to 52 families, or 246 people in all.

Several of the girls are active in different clubs, many being officers or committee members.

The Washington Water Power Company—

During the past year it has been hoped that there might be an opportunity whereby the girls interested in electric cookery could come into the kitchen and actually work with the electric appliances.

The employee information program was being carried out in general company meetings, and it had been thought by the management that this would take the place of the regular meetings of the women's committee. However, many of the girls were reluctant to give up the committee work, so it was then decided that the cooking classes be continued as a women's committee activity.

The purpose at the outset was to give a knowledge of the advantage and economical use of the various electric appliances. Thirty-three girls have reported very faithfully.

Mrs. Ramirez, who is home economist of the company, is acting as chairman of the women's committee. Needless to say, their meetings conducted as cooking classes, have been very instructive and beneficial. Among the appliances which they use in their classes are: range, percolator, electric mixer, refrigerator, fruit-juice extractor, waffle iron, egg cooker and toaster. Each class consists of from nine to twelve girls, divided into groups of three or four, with three in each group.

The Christmas charity program was carried out as usual. The need seemed greater than ever before. Each committee member gave 75 cents toward the Christmas fund and there were many donations made by the men employees, as well as by others who were interested in the cause. Six families, totaling 35 persons, were provided with necessary clothing (which was also donated by employees), fuel, groceries and staples enough to carry them through the hardest part of the winter. The actual amount spent for food for these families was about $75.

The home economist was asked by the Y.W.C.A. to give talks to a "maids' class" on the construction, care and economical use of electric appliances. Several demonstrations were held there, showing the appliances in operation.

The Spokane Women's Club holds a waffle breakfast yearly and the committee has an active part in the carrying out of this event.

On December 28 Mrs. Fern T. Hubbard gave a demonstration of the Hotpoint range before the entire group of the Spokane women's committee.

Mountain States Power Company—

Margaret Hurst gave a brief report on the activities of the women's committee in her organization. They had a dinner meeting in December. This group is doing some work in first aid, and are very active in the drive for unemployment. The employees' information program is being carried on.

Idaho Power Company—

On account of illness Mary Newhouse, chairman of this group, was unable to attend the meeting. However, we were very happy to have Mrs. McDevitt with us, and the following report, prepared by Miss Newhouse, was presented by Mrs. McDevitt:

The September meeting was an organization meeting, at which was outlined the year's work. Mrs. Villa, retiring chairman, was presented with a small gift as a token of appreciation of her work as chairman. The president of the Business and Professional Women's Club of Boise gave a very interesting talk on her experience in visting the Bell Laboratories in New York. Plans were made to have a class in swimming.

At the October meeting, the Boise division manager gave an exceptionally interesting talk on the construction, site of, and facts about the Boulder Dam.

At the November meeting, several of the girls gave current topic talks, either of an electrical nature or on something of interest to women. A talk was given by the sales manager on electrical merchandise sales, merchandising activities and national and local merchandising programs.

In addition to a Christmas luncheon and program, a very interesting talk was given at the December meeting by the lighting engineer of the company, his subject being "Light as a Partner to the Eye." At this meeting the treasurer reported the returns of the turkey raffles which were conducted to raise money to help a poor family at Christmas time.

In January, Mrs. McDevitt talked on the use of electricity in the home and explained the new speed unit on electric ranges. At this meeting a number of the girls decided to sign up for the supper classes which are conducted at the high school by Mrs. Wood, food instructor.

February was a luncheon meeting. The program was a talk on the G.E. refrigerator, by S. J. Gray of the Boise division sales department.

The group has now organized a swimming class.

The California Oregon Power Company—

This group is presided over by Viola Templeton as chairman. This committee has a different program chairman for each meeting. At one meeting a very interesting paper was read by one of the girls, explaining the relationship between the company and the holding company. This was followed by a showing of films taken by the advertising manager of the company, dealing with incidents of interest to the company during the current year.

Mrs. Alan Brackinreed gave a talk at the November

meeting, on "The Use of English and Its Benefits to Us." The girls were offered a course in the Miller system of correct English, and eighteen girls signed for the course. The class meets every Monday evening at 7 o'clock, and much enthusiasm has been evinced.

One meeting was held at the home of Estella Dorgan. Miss Dorgan demonstrated the General Electric ironer, the Starlite magic maid and the Dormeyer mixers. Ways of cooking on stored heat were explained and the use of the fireless cooker demonstrated on the Hotpoint electric range.

George Phythian, construction engineer of Chicago, spoke at the January meeting, showing films of construction work being done by his department at Keno Reef in the Klamath River, and on the diversion canal at Prospect, discussing both projects very thoroughly. This was exceedingly instructive as well as interesting, as most of the girls were familiar with the territory covered.

In February the girls visited the Medford substation and listened to informal explanations of the uses of the various pieces of equipment.

Puget Sound Power & Light Company—

There are seven districts in this company, each having a women's committee, with Mrs. Nell Laws as general chairman, each group having its individual chairman. In some of the districts the meetings are being held bimonthly this year. Nell Marks, treasurer of the women's committee in Seattle, has given a most interesting talk before most of the groups on her trip to the national convention of Business and Professional Women's Clubs, and her visit to electric companies throughout the east and south, including the company headquarters in New York.

At the November meeting of the Seattle group, Evangeline Starr, president of the Seattle Business and Professional Women's Club, gave a talk on "Employment Relief for Women in Seattle." The committee, following this outline and appeal, took part in a city-wide fund-raising project in December.

Various interesting talks have been given before these groups, such as —"Rates," "Promotion of Sales," "Taxes," "Old Age Independence," which was given in connection with Thrift Week, "Problems of the Company and the Part Women Can Take in Assisting," and "Women's Place in the Electric Industry."

Very constructive Christmas charity work was done by all districts, financed by the company women's committees. About fifty families were assisted, food supplies being supplied for several weeks. Clothing was also given. Two groups assisted with local milk funds, others helped the local charity funds. Some of the groups have followed up the work and have assisted the families since. In Seattle a number of opportunities have been presented to help ex-employees or those temporarily in distress.

All districts have representatives in the Business and Professional Women's Clubs.

The Seattle group assisted the home economist by serving coffee and cake to guests in the office building, who were visitors there after leaving the large Daily Times cooking school in the theater across the street from the office. This serving was carried on each afternoon for a week; 3,000 persons were served in all. Many compliments were paid to the office women for the delightful way in which the visitors were served.

During December five of the district women's committees had cooking schools, in charge of Mrs. Fern Hubbard. Complete dinners were prepared by the members and some interesting ideas in electric cookery were brought out. A sixth group had Mrs. Hubbard for a special talk on electric cookery, in the evening.

Four of the district women's committees have girl's bowling teams. One team (from Everett) has been very successful and has twice beaten the men's teams there, playing on an equal basis.

In January the Wenatchee women's committee presented the playlet "Wanted—A Stenographer," before the Wenatchee Elks, at an entertainment.

The Bremerton group has this winter had representatives in a community play put on by a group of service clubs. Also it has had a part in community projects of various kinds. They also put on "Wanted—A Stenographer," for the Active Club in Bremerton. This committee numbers only nine members.

Utah Power & Light Company—

This committee, with Mrs. Margaret Schofield as chairman, has been following the program as suggested at the beginning of the year by Miss Cummings, chairman of the Northwest women's committee. A very interesting meeting on "Home Lighting" was held in December. The January meeting was given over to the preparation of breakfast, using various electrical appliances. Mrs. Welch, home economist, asked two girls to help in the demonstration, and a very interesting and instructive meeting was enjoyed. Preparation of luncheon and dinner was the feature of the February meeting. Ruby Smith, our other home economist, conducted this meeting, assisted by two girls from the committee. These meetings seem to appeal to the girls, and have been very instructive. The balance of the meetings for the year will be devoted to the uses of various household electrical appliances.

Pacific Power & Light Company—

There are no committee meetings conducted by this company, due to the widely scattered territory. However, Gertrude Humphrey is cooperating in every way possible, by sending to the women of her company information pertaining to the industry.

Safety Committee

Mrs. Laws, chairman of the safety subcommittee, submitted her report, saying that she had written to different girls asking them to plan safety programs. She encouraged chairmen to remember the first aid work, and asked for pictures of the teams and first aid plays. Miss Laws read Miss Butler's message on first aid in her company, which is as follows:

> Our five-girl women's first-aid team gave demonstrations before the Kiwanis Clubs of Gresham, Ore., and Vancouver, Wash. They also assisted in teaching a class of nurses in the Medical-Dental Building, and a class of physical education directors of the public schools.

Home Service

Mrs. Welch, chairman of the home service subcommittee, reported that at the beginning of the year she sent to the home service girls of the Northwest Division, a "get acquainted" letter, asking for a report of activities, to which some of the girls have replied, but as yet no reports as to their educational work among women of their community have been received.

It was urged that the chairmen ask their home service girls to make reports to Mrs. Welch on the work being done in the various companies.

Mrs. Welch gave a very interesting report of the

work being done in her company. The home service workers of the company meet each morning at 8:30 with the salesmen, ready to answer questions asked, or discuss with them new problems they may have. In their electrically equipped kitchen, which is combined with the sales auditorium, the major appliances are connected and in full operation, giving the salesmen an opportunity of really showing prospective purchasers these appliances in operation. At demonstrations the smaller appliances are also brought in.

It was Mrs. Welch's suggestion that the salesmen of the company invite some of their prospective appliance purchasers to attend a demonstration to be given by one or more of the home service workers, as those attending such a demonstration will ask questions, and learn many interesting facts concerning these appliances. It has been her experience that at the close of some of these classes, sales have been closed. At these demonstrations the smaller appliances are brought before the people. Many people look at these appliances in the store as though they were just ornaments, and much enthusiasm is manifest in them at these demonstrations.

Much may be accomplished in working with the various schools. In this connection, the Utah Power & Light Company has been exceedingly successful. Classes have been conducted under the supervision of the home service girls. The University of Utah has just recently purchased two new electric units, making a unit kitchen. The University now has a home service room, as suggested by the N.E.L.A., showing every electric appliance, correct lighting and wiring. Four classes have been conducted under the direction of Mrs. Welch on the uses of electric appliances, beginning with the electric mixer.

It has been suggested that the women's committees have demonstrations of electrical appliances, both large and small, showing the uses of them day by day, meal by meal, bringing out the art of living electrically.

There being three home service workers present at the meeting, there was a very interesting discussion of this phase of women's committee activity.